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**The creation of a railway junction in the  
centre of Brussels.****Review of the arrangements and prospective operation,**

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## FOREWORD

As a civil engineering work, the junction now being built in the centre of Brussels has already been the subject of articles in many technical reviews. The present article is intended to describe certain aspects of this junction taken as a railway installation.

the first railway line on the Continent as far back as 1835, and this has developed into the present very close knitted system of some 4 900 km. (3 045 miles) of lines (fig. 1).

At the centre of this system lies Brussels, a capital with 935 000 inhabitants, and

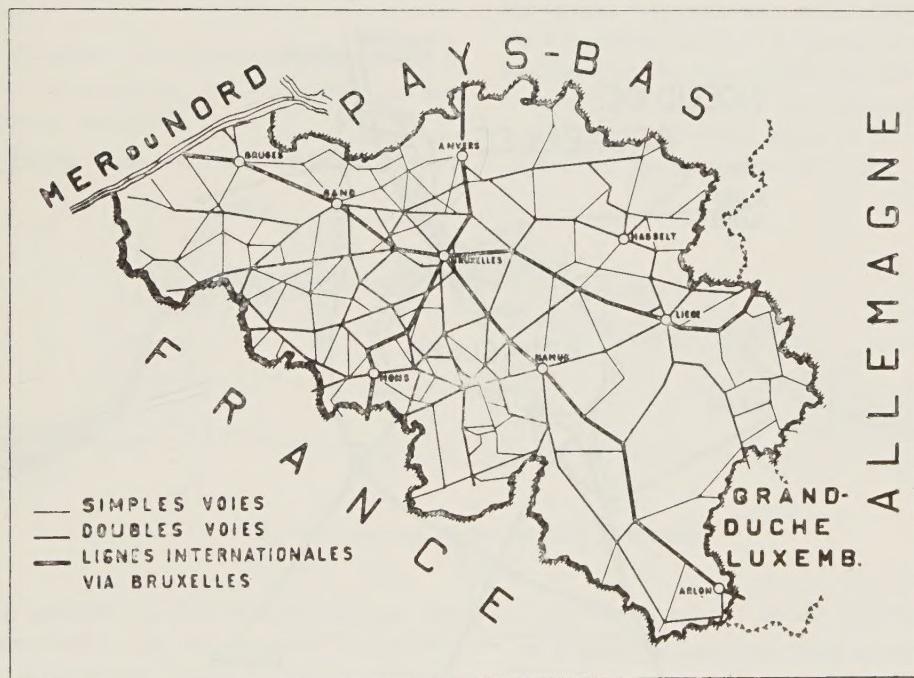


Fig. 1. — The Belgian railway system. — Diagrammatic map.

*Explanation of French terms.*

Simples voies = single tracks. — Doubles voies = double tracks. — Lignes internationales via Bruxelles = international lines via Brussels.

## CHAPTER I. — INTRODUCTION

### I. — BRUSSELS — Railway centre.

Belgium, a small, very industrialised country, with a dense population (\*) had

the most important railway centre in the country.

The eight main lines carry a total of some 220 000 passengers in and out of Brussels every day.

From the international point of view, the Belgian capital is a place of transit for railway traffic from England to Switzer-

(\*) 8.5 million inhabitants in an area of about 30 500 km<sup>2</sup>, i. e. nearly 280 inhabitants to the km<sup>2</sup>.

land and Germany as well as from France to Holland (fig. 1).

Besides a certain number of secondary stations of varying importance, there are two main line dead end stations in Brussels, the Nord and Midi, serving the two distinct parts of the system (fig. 2).

only 3 km. (1.86 miles) apart as the crow flies.

## II. — The Nord-Midi Junction.

### 1. *The beginnings.*

The building of the Nord and Midi Stations in 1842 and 1869, both as ter-

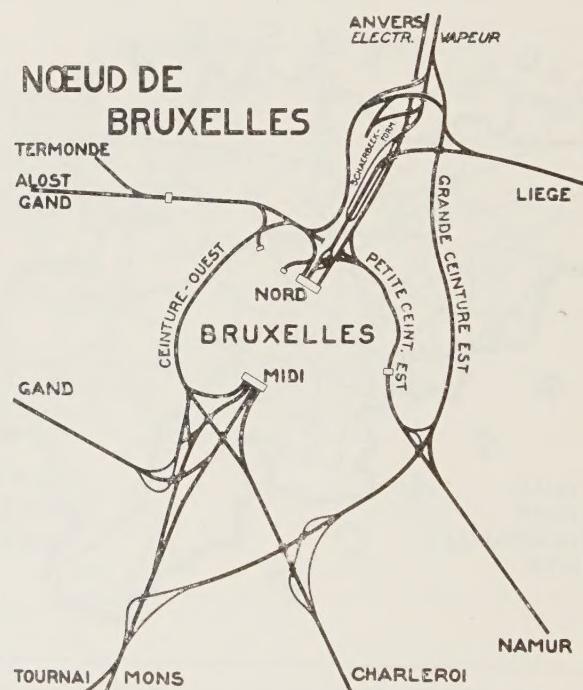


Fig. 2. — The Brussels railway centre.

Although they are connected by the « Ceinture » railway, these two stations are terminii for two separate systems.

The organisation of passenger trains to each of the two main line stations in turn is of no interest to the public, as such trains have to back out and make a detour of 11 km. (6.8 miles) to get from one station to the other, though they are

minii, brought about as from that time the principle of a station for the use of each half of the system.

This principle has remained unchanged in spite of the transformations which the two stations have undergone, and the creation of a railway centre with an inner-circle line.

Already before 1900, the increase of

traffic was such that the two stations were inadequate and public opinion has been concerned with remedying this.

In its development Brussels has continued to engulf the two stations ever more deeply, which has increased the obstacles in the way of urban traffic due to the railway lines built on ground level.

A radical transformation, equivalent to the construction of two new stations seemed inevitable.

Faced with undertaking such a task,

The carrying out of the project came up against a great many obstacles.

Though decided upon in 1901, permission to go ahead with the Junction was only given in 1911 to be interrupted almost immediately by the war in 1914.

After the war, discussions were resumed regarding the opportunity of continuing the work. It was not until 1935 that the Chambers set up « A National Office to complete the Nord-Midi Junction ».

Since 1935, the work was actively continued, but had once again to be interrupted by the recent world war.

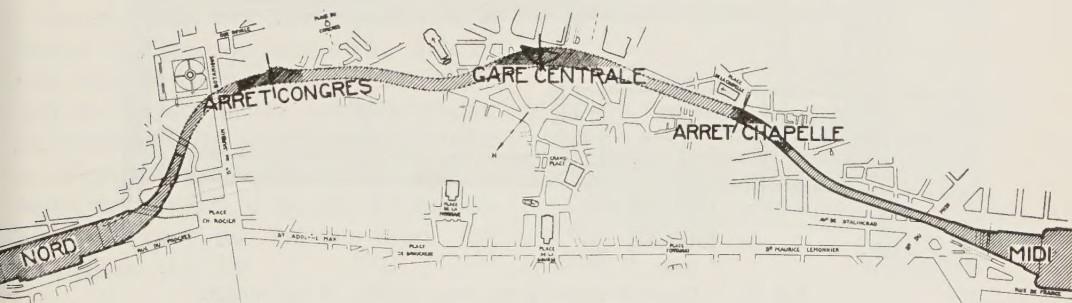


Fig. 3.— Layout of the Junction in Brussels.

the problem of the Brussels railway services had to be re-examined as a whole.

In particular, it was necessary to decide whether the two stations should be directly connected by rail through the middle of the town.

This Junction, which has been under consideration for many years, meets in particular the desire of the city to have an additional station near its commercial and administrative centre.

After investigating a great many proposals, the Government Commission unanimously adopted in 1901 the plans of BRUNEEL for a direct junction.

## 2. Characteristics of the scheme.

A 6 track railway line links up the two new stations with elevated lines.

We will consider the scheme from the point of view of the stations later on, and content ourselves for the moment with the Junction properly speaking.

It is necessary to point out to begin with that the making of a direct junction with track below the level of the ground, both in the stations and in the city, had to be abandoned owing to the boggy nature of the soil. The two stations as well as the centre of the city lie in fact in the valley of the Senne.

As for making the connection entirely by viaduct, this had drawbacks not only from the æsthetic point of view, but also because of the loss of space in the city it entailed.

To reduce these drawbacks the plan provided for a layout which limited the viaducts to those needed to reach the side of the hill beside the valley into which the lines could be run in tunnel (fig. 3).

Thus out of 3 600 m. (3 937 yards),

Each of these stopping points consists of two platforms served in passing by four of the six lines of the Junction.

It may be added that the gradients in no case exceed 5 mm./m. (5 %).

### 3. The objects.

The complete plans for the Junction implied the suppression of the two terminii stations and their replacement by two through stations.

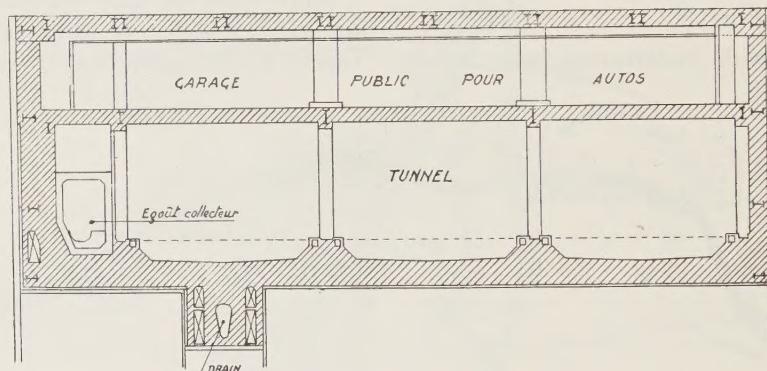


Fig. 4.—Diagram showing the cross section of the tunnel.

1 900 m. (2 078 yards) of the junction area tunnel.

By avoiding certain historical monuments, the layout took care not to involve the destruction of anything irreparable which explains the relatively tortuous lines, though all the radii are more than 245 m. (268 yards).

About half way between the two stations lies the Central Halt which is served by the 6 through lines without any other installations.

On each side of the Central Halt, approximately half way between it and the two stations, are two stopping points, one in the tunnel, and one on a viaduct.

At the time this plan appeared to the Commission to have the following main advantages :

1. Suppression of the drawbacks resulting from the operating of restricted termini by steam traction.
  2. Improvement of the town rail services by making the whole of the system accessible from the two stations, and the providing of new points for joining and leaving trains right in the centre of Brussels.
  3. Improvement of the inter-provincial services by making it unnecessary for passengers to change between the two Brussels stations.

It should be noted in passing that owing to the long delays in carrying out the work, the first two advantages have been considerably modified.

The introduction and development of electric traction has appreciably reduced the drawback of dead end terminii as a result of the use of railcars.

On the other hand, the growth of Brussels in population, the absence of a metro and extensive bus services have led to great congestion of the tramways which is increased by general traffic difficulties.

At the present time, the problem of transport in the city makes a solution to obtain its dispersion imperative. Side by side with the electrification of the system and the growth in the suburban traffic, the Junction will appreciably contribute to relieving the urban transport by giving better distribution of the 200 000 passengers who use the railway every day throughout the city.

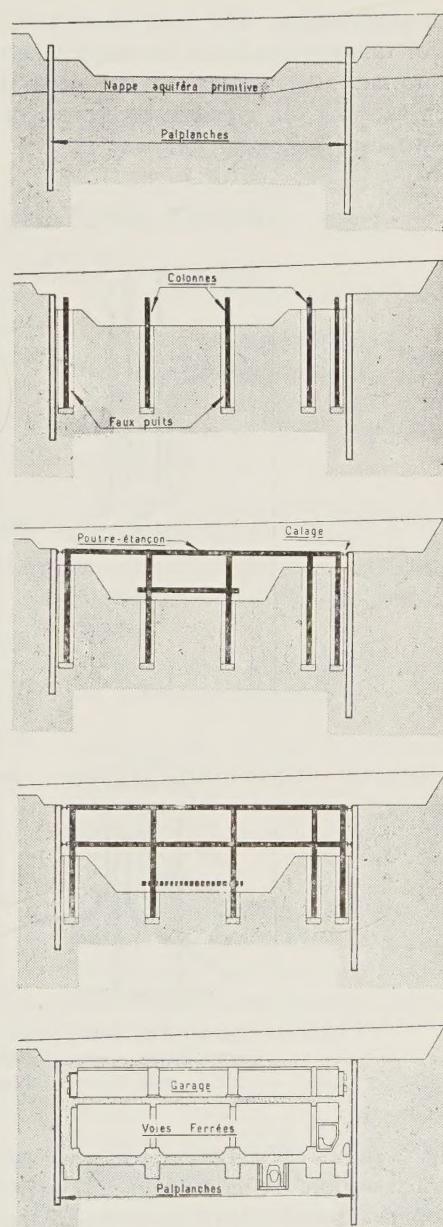
#### *4. Method of carrying out the work.*

Let us briefly recall the principle of building the tunnel.

The 6 tracks of the Junction are divided into pairs in the tunnel which is about 35 m. (38 yards) wide divided into three adjoining portions separated by rows of columns (fig. 4).

The nature of the soil (Ypres sand) as well as the small depth below ground (the floor is never more than 16 m. [17 yards] down), made the classical methods of tunnel construction inapplicable.

A process devised by the late M. FRANCHIMONT, Chief Engineer, General Manager of the Junction Office, was used



(Cliché Ossature Métallique.)

Fig. 5. — Process of building the tunnel.

most successfully. The chief characteristics of this process lie in the steps taken to prevent any shifting of the ground when carrying out work in the centre of a town near historical monuments.

connected by longitudinal and transversal stays which hold up the curtains of piles.

The earthwork is then excavated under the protection of this framework which is extended as the section is excavated (\*).

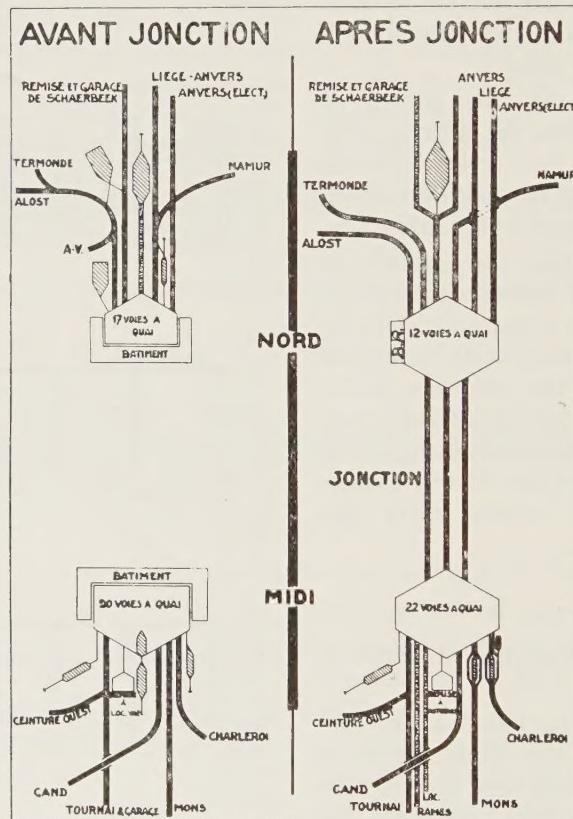


Fig. 6. — Nord and Midi Stations.  
 Comparative diagram showing the installations before  
 and after the Junction is completed.

Fig. 5 shows the stages of the work in a normal section. After driving a curtain of sheet piles on each side of the section to be excavated, pits dug where the columns will be made, enabled metal columns to be put in position. These columns are

Concreting and encasing the metal framework is then carried out in the

(\*) The excavation of the pits intended to hold the columns necessitated first of all dealing with the water-bearing strata by means of drainage pits.

opposite direction working from the floor of the tunnel upwards.

In some places, slight variations had to be made in this method. Mention must again be made of three singularities of this tunnel :

1. The existence of a drain alongside the tunnel on the hill side.

The tunnel cuts 18 main sewers running down to the valley. In order to avoid having to make costly syphons under the tunnel, it was decided that it would be cheaper and safer to connect the 18 sewers to a main drain which connects with the town sewers beyond the tunnel.

2. The existence of a sewer under the tunnel to make sure there will be no hydrostatic pressure under the floor.

3. The north end of the tunnel is made in two divisions instead of 3 for some 125 m. (136 yards) in order to make room for the first ladder tracks of the Nord station.

## CHAPTER II.

### THE JUNCTION AS A WHOLE.

#### I. — The railway complex.

First of all it must be pointed out that the plans made for building such an important railway installation right in the centre of a city could not be inspired wholly by operating considerations.

The choice made had to take into account the technical and financial possibilities, and topographical conditions as well as town planning and architectural considerations.

This must be borne in mind when

considering the results wholly from the « railway » point of view.

It must also be stated that as for various reasons the carrying out of the work has extended over nearly half a century, it is difficult to obtain a completely harmonious result.

#### 1. *The stations and the Junction.*

Two double outlet stations, at a higher level than the former ones, and connected by 6 track railway lines, will take the place of the old Nord and Midi stations (fig. 6, 7 and 8).

The two new stations are a few hundred yards further the centre of the city in order to reduce the acquisition of land essential for the ladder tracks to the Junction.

The general plan (fig. 6) is based on the following conceptions :

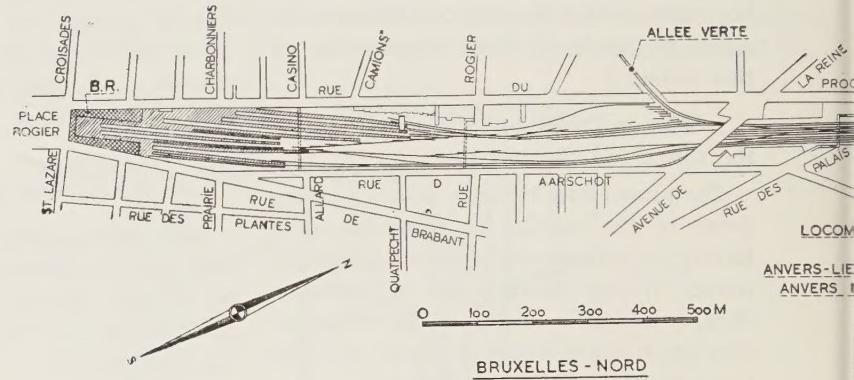
a) As the layout is continuous, it is possible and desirable to concentrate in a station all the traffic movements, in particular alterations in the composition of trains.

This idea leads to the provision of a station equipped with important track installations, and another limited to the installations indispensable for the operation of through trains.

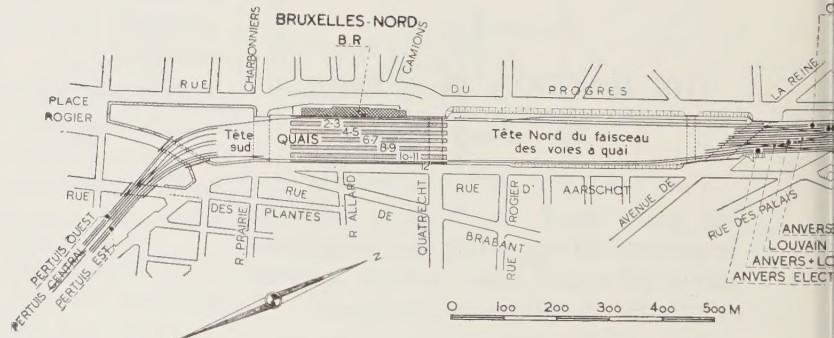
b) The junction lines as well as the platform lines of the two end stations — Nord and Midi — are operated by *line* and not by direction.

Local topographical conditions supported the choice of these arrangements :

1) The site available for the Nord station was only 110 m. (120 yards) wide.

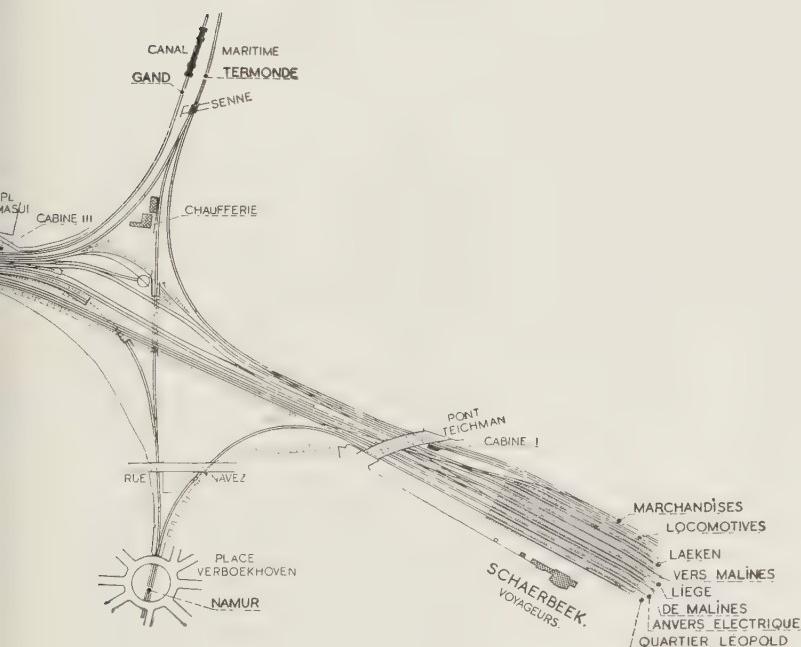
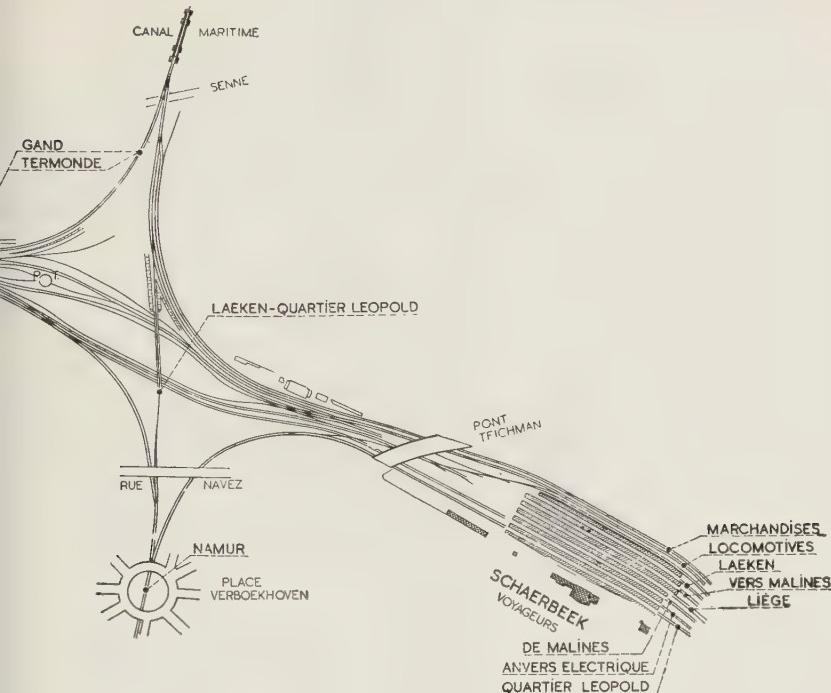


### INSTALLATIONS FERROVIAIRES SITUATION EN 1936



### BRUXELLES - NORD. INSTALLATIONS FERROVIAIRES A REALISER EN VUE DE LA JONCTION NORD-MIDI.

Fig. 7. — Nord Station, the  
Railway installations as in 1936. — Railway i



ment and the new layout.  
be completed in view of the Nord-Midi Junction.

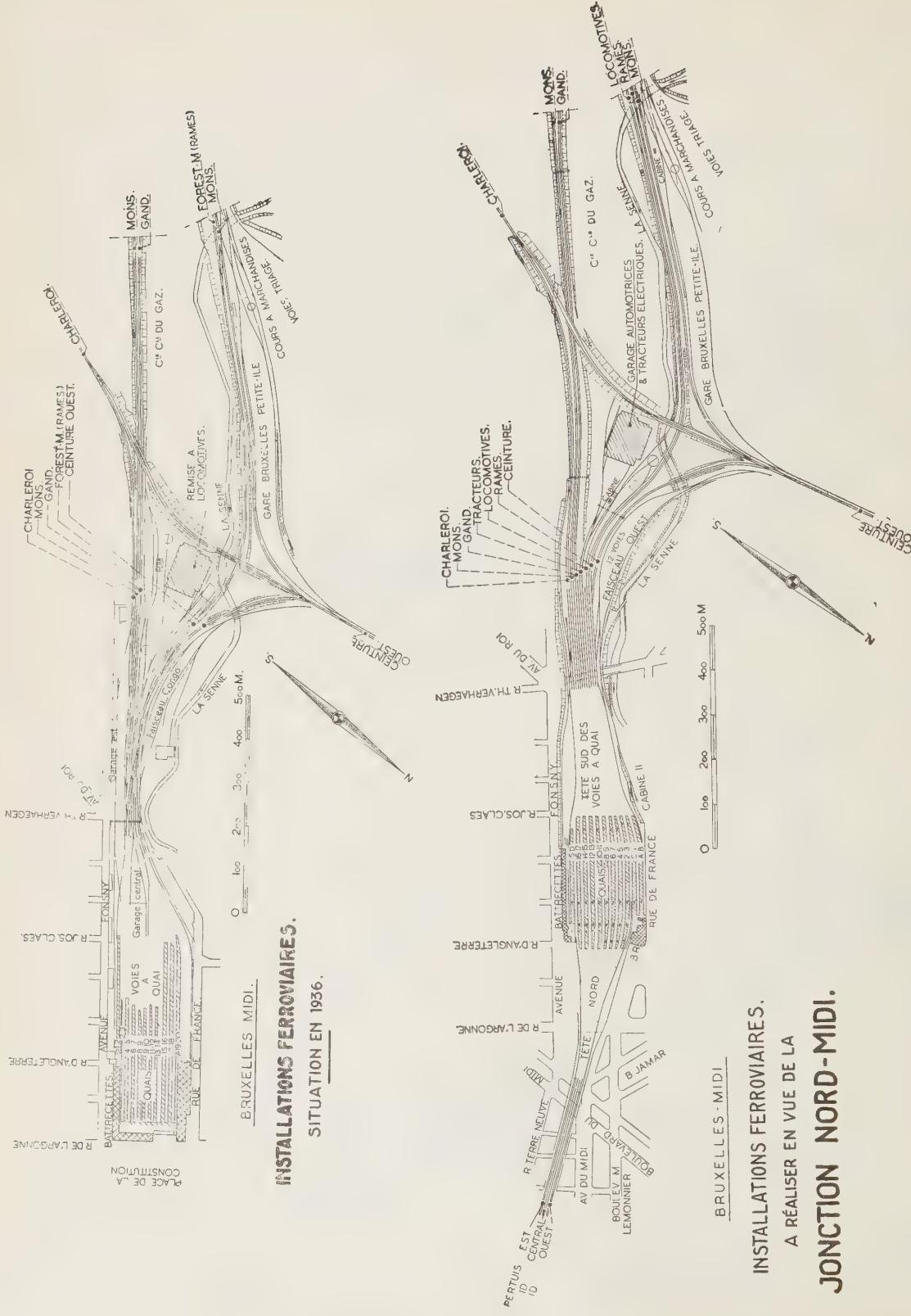


Fig. 8.—Midi Station, the old arrangement and the new layout.

As it was desired to reduce to the minimum costly requisitioning of land, the building of a new station with many lines would have involved too narrow platforms and the construction of a building under the track.

A building of this kind involves greater first costs and maintenance costs than a building at the side.

The final choice therefore for the Nord station was 12 platform lines (fig. 7) corresponding to the 12 main lines running into the station, with a building at the side.

This arrangement determined the operating methods for through working to be used in this station.

In the case of the Midi station, the site available was considerably wider (200 m. [218 yards] instead of 110 m.), so it was possible to provide 22 platform lines (18 through and 4 dead-end). It was necessary however to have a building under the track.

2) The operation of the two stations, the 12 platform lines of the one and 18 lines of the other of which are linked by 6 main lines would have given the maximum facilities if the whole could have been arranged according to direction.

This would have resulted in the well known advantages of doing away completely with intersections and complete independence between the traffic in each direction.

The decision to remain content with an arrangement according to lines (fig. 6) was due to the following considerations :

— an arrangement by « lines » was already in existence on all the lines ending in the two stations;

- it was impossible to fit the installations required for operating by direction between the platforms of the two stations and the junction;
- it was difficult to arrange for operation by « direction » at Brussels Nord on the opposite side to the Junction. All the main lines only run in parallel some 500 m. (546 yards) beyond the station.

As the urban traffic and the level of the Junction made it necessary to raise the level on the main lines by nearly 9 m. (9.84 yards), it would have been necessary to build up many of the structures over this short distance.

Even if this problem could have been solved technically, the cost would have been considerable.

## 2. The main lines.

The arrangement of the main lines ending in the two stations is due in turn to two guiding principles :

1. The requirements involved by operation by « line » of the 12 main lines reduced to 6 lines in the junction, made it essential that the timetables on the lines to Brussels should be independent.

The complete independence of the lines as far as the platform makes it possible to let the two stations play the part of a regulator for the junction, thanks to the stopping times.

Considerable work has been done and is still being carried out to achieve this end.

*In the Nord Station.* — In the old station (fig. 6) 6 lines ran into the station as 3 double main lines.

In the new station (fig. 6) these 6 lines are kept separate as far as the platform.

This layout involves :

- doubling as far as the station the lines from Alost and Termonde which are at present one line as from Jette (Fig. 2, 6 and 7). This work remains to be carried out;
- the doubling of the lines from Antwerp (steam) and Liège (Fig. 2, 6 and 7) between Schaerbeek and Brussels (Nord). This work is in hand but not completed;
- independent entry of the line from Namur, which is partly completed.

*In the Midi Station.* — As space is less limited, the general layout already makes possible the separate entry of the 4 lines.

However the lines from Mons and Tournai made separate from Forest (Midi) to Brussels (Midi) have still to be doubled up to Hal.

2. In order to reduce the cost, the topographical arrangement of the lines at the entry to the two stations had to be maintained as far as was compatible with operating requirements.

Only one modification was necessary at the Nord station, where a tube made it possible to run the Namur line under the Antwerp(electric) and Liege lines. This modification was due to the considerations given below.

### 3. *The supplementary installations.*

As the arrangement of the main installations was decided, the supplementary installations had to be adapted to the new situation.

#### Carriage sidings.

The increase in the number of main lines and the bringing of the two stations further from the centre of the city considerably decreased the possibility of stab-

ling carriages close to the platforms. Fig. 6 illustrates the position.

Brussels Midi still has a few carriage sidings in the station, whereas the group of sidings nearest to the Nord station are some 1 000 m. (1 093 yards) away.

Both stations have very extensive carriage sidings some distance away : at Forest (2 400 m. = 2 625 yards), in the case of the Midi and at Schaerbeek (4 500 m. = 4 921 yards), in the case of the Nord. The Forest sidings have been completely rearranged to suit the Junction.

It may be mentioned in passing that all the sidings near the stations had to be raised in level like the main lines.

#### Sheds.

##### Steam locomotives.

Both the Nord and Midi Stations have a locomotive shed. The Schaerbeek shed, which can hold 200 locomotives, covers the Nord Station and the largest marshalling yard on the system : Schaerbeek (Marshalling).

When making the Junction it was necessary to give Brussels Midi a new shed at Forest (able to take 125 locomotives). The raising in level of the station and its new site destroyed the old shed which was quite close to the station.

Both stations are equipped with locomotive turntables and ash pits.

Only Brussels Midi is equipped with water columns on the platforms.

#### Railcars and electric locomotives.

The maintenance of the electric locomotives and railcars is concentrated at Schaerbeek in a special shed until the electrification of the railway reaches a further stage of development.

### Railcars.

The maintenance of this stock is concentrated in a covered shed at Brussels (Midi) (fig. 8). This was the old locomotive shed which has been completely reorganised for its present use.

### 4. Services between stations, carriage sheds and sidings.

The Midi Station is linked up with its shed and sidings at Forest by two separate lines, one for locomotives and the other for rakes of stock. As a result of the proposed operation of the Nord Station, only a single line for both locomotives and stock links it up with the Schaerbeek installations. This line joins up with the main line some distance from the station (fig. 6).

\*\*\*

## II. — Operation of the « Junction » as a whole.

The operation of a railway system involves a very wide awake technique which can be adapted as required to circumstances.

It is therefore necessary to be circumspect when making long term plans.

The operation described below must only be taken as a general programme which will certainly be modified in practice to a greater or lesser extent.

For the same reason, the figures given are only estimates which the future alone can correct.

Until the Junction is put into service, there remains an unknown factor : the reaction of the public to the new possibilities offered. This reaction will determine in the end the final operation.

### 1. The traffic.

The operation considered for the « Junction » depends on two main factors :

1. The object of the junction : to multiply in the centre of the city of Brussels, the places at which trains can be joined or left from all parts of the system.

To achieve this end completely all the trains which stopped at the Midi terminus station must in the future continue their journey as far as the Nord. Likewise those from the Nord must continue on to the Midi. In the same way, all the trains leaving Brussels must run through the Junction.

2. The arrangement of the Nord Station designed to be a through station.

To realise the first factor completely would have meant more than 120 services an hour at peak hours on the 6 lines of the Junction, which is impossible.

The outlet of the 6 lines is limited by various elements : operation by lines at the end stations, i.e. with intersections at the entry to the Junction, non parallel time tables, block sections.

The services must therefore be reduced to a possible level, whilst taking care not to diminish the usefulness of the Junction.

The natural thing to do is to organise the operation of the lines ending at the Nord and Midi Stations in such a way as to enable trains to be coupled up for one movement through the Junction.

In this way an Antwerp-Brussels-Charleroi train will only involve one run through the junction, whereas two would have been required if the trains from the Antwerp and Charleroi lines remained separate (fig. 9).

Coupling up in this way presupposes:

- a certain similarity in the traffic;
- identical means of traffic in each case, whether steam or electric.

Coupling up lines in this way should also lead to useful interprovincial services.

It is not advisable to start a new service

the foregoing considerations make the following coupling up of services seem advisable:

- Antwerp-Brussels-Charleroi; the first of these lines has been electrified since 1935, whilst the second is now being electrified;
- Liege (Verviers)-Brussels-Ostend, to which may be added after electrification an outer suburban service from Louvain-Braine-le-Comte.

### SANS ACCOUPLEMENT 2 circulations



### AVEC ACCOUPLEMENT 1 circulation



Fig. 9. — Traffic in the Junction, without and with coupling lines together.

between two provincial towns which are already connected directly by a shorter route with good services.

For example coupling together the Namur and Charleroi lines would not be any improvement from this point of view, as there are already excellent through services between these two places.

It should also be noted that interprovincial traffic alone does not justify the setting up of such services. There must be an appropriate combination of circumstances for the proper method of operation of a junction.

In the present stage of the investigations,

#### Operation of the Nord and Midi Stations.

##### Nord Station (fig. 7).

The operation of the Nord Station depends on the idea of its layout as a through station. It is therefore desirable to make as few back movements as possible.

No problem arises in the case of the trains on the coupled up lines, nor in the case of trains from the northern region continuing on towards the south.

Special measures are only necessary in the case of trains from the south to Brussels or vice-versa.

It is proposed to take these trains out to the sidings at Schaerbeek. They can then be considered either as trains whose last stop is Schaerbeek, or as a rake from the Nord Station. In this station, the holding sidings between the main lines make it possible to remove the rakes from the platform lines and send them on to Schaerbeek as convenient.

In the same way trains formed at Brussels which will run through the Junction in the north-south direction are formed in the Schaerbeek sidings and start their journey either from Schaerbeek or from the Nord Station.

#### Midi Station.

The 22 platform lines in the Midi Station allow greater latitude as regards operation.

The 18 through lines make it possible for trains to remain longer at the platforms than in the case of the Nord Station, and in particular trains can be sent back in the direction from which they have come.

The existence of 4 dead-end lines also makes it possible to consider the formation of special or seasonal trains which the Junction cannot absorb.

#### *2. Train services and distribution of the traffic in the outlets from the Junction.*

A detailed report of the proposed train services does not come within the scope of this study.

It may be remembered that a programme has been drawn up for the electrification of the system covering 1 500 km. (932 miles) of lines. This

programme will be completed according to financial possibilities.

#### Interior services.

A service based on a rhythm of one through train per hour during the slack hours and one through train every half hour in the rush hours is proposed between Brussels and the chief provincial centres.

Electrification will make it possible to introduce an intensive outer suburban service so that there will be 4 trains every half hour on the more important lines at rush hours.

These 4 trains will consist of one through train, two semi-direct and one stopping.

It is also proposed in the case of the electrified lines that in no case shall the services drop below one per hour during the slack hours for each kind of train, i.e. one through train, one semi-direct and one stopping train an hour.

In principal the basic service (slack hours) can be worked entirely by electric railcars. The type used are double railcars which can be coupled together. The services are increased during rush hours by using reserve railcars released from maintenance and by running supplementary trains. These trains consist of metal coaches of the usual type in service on the Belgian railways, hauled by mixed traffic electric locomotives.

This is an attractive solution because it avoids the unproductive immobilisation of such costly stock as railcars during slack periods; the mixed traffic locomotives can be used to haul goods trains at these periods, especially during the night.

The use of electric locomotives for combined services — passenger-goods — will depend however upon the results obtained by actual experience.

This programme will adapt itself the better to our conditions when we have metal coaches on our system.

#### International services.

For certain international services the junction forms the shortest route for passing through Brussels.

The Amsterdam-Paris and Ostend-Bale trains and vice-versa, obliged to reverse at the present time, the former in the Midi and the latter in the Nord, will run through the Junction.

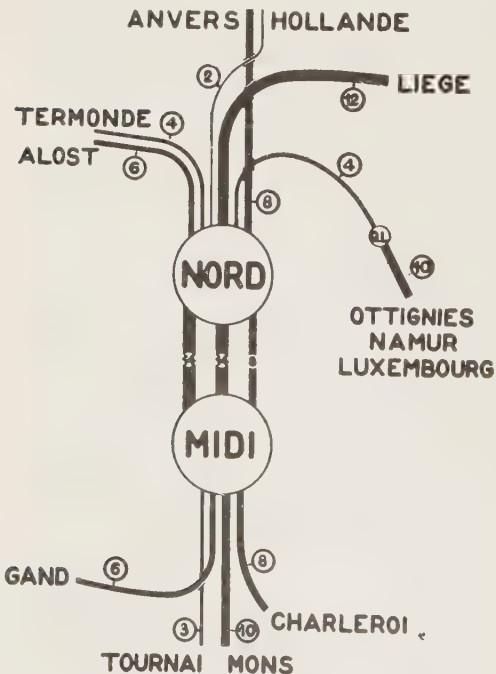


Fig. 10. — Peak traffic in the Junction, per hour for each direction.

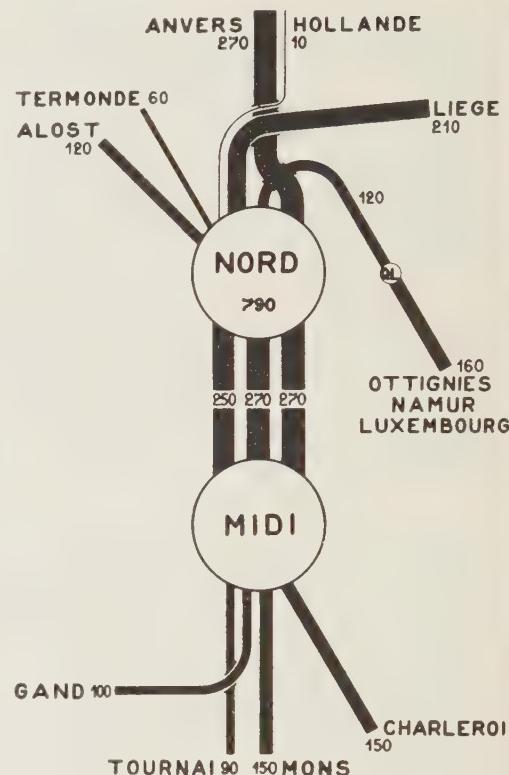


Fig. 11. — Traffic in the Junction for a 24 hour period.

The route to be taken by the Amsterdam-Bale trains which at the present time reverse in the Nord Station has not yet been decided.

#### Traffic in the Junction.

Figs 10 and 11 show the traffic expected in the Junction and on the lines leading to it, during a rush hour and a slack hour respectively.

Present estimates are that about 790 trains a day will go through the Junction, divided about equally between the three outlets, i.e. an average of 33 an hour.

The traffic at rush hours will amount to 72 trains for the 6 lines, with a maximum of 14 services on certain lines (fig. 10).

#### **Use of the Central Halt and stopping points.**

All the interior services will stop at the Central Halt (one minute stop). The problem of the possible stopping of international trains at this halt is still under consideration.

The stopping points at « Congrès » and « la Chapelle » are intended for the suburban and outer suburban traffic. The stopping and semi-direct trains using the Junction lines « Est » and « Central » will stop there.

The limited length of the platforms (200 to 225 m. = 218 to 245 yards) makes it impossible to stop heavy trains at them.

\*\*\*

#### **3. Organisation of the luggage services.**

As there are only 12 platform lines at the Nord Station which are all through lines, it is not possible to let trains stop for any length of time. The organisation of the luggage services therefore must be directed towards reducing the handling involved as much as possible. The only luggage handled in this station therefore will be : on departure, luggage sent in for registration; on arrival, luggage which the passenger has asked to be unloaded at the Nord.

All luggage to be delivered home will be sent to the Midi Station, where the luggage haulage services are centralised.

The Central Halt has no luggage installation. Nor have the stopping points for even better reasons.

#### **4. Organisation of the parcels traffic.**

The two stations include goods depots for the acceptance of express parcels and postal packages.

Express parcels are sent off during the day as received.

Postal packages and express parcels accepted at night are sent on at night by express goods train. The formation of these trains is centralised at the Midi Station which is specially equipped for this purpose.

#### **5. Various.**

The operation of the Junction gives rise to a great many problems which cannot be examined in the present article. We will mention however the fares problem, and that of seat reservations in trains passing through the Junction.

\*\*\*

### **III. — Traffic through the Junction.**

#### **1. Speed.**

It has been found advisable to limit the speed through the Junction properly so called to 50 km. (31 miles)/h. with a

#### **SIGNALISATION A REPETITION SIMPLE DANS LA JONCTION.**



Fig. 12. — Simple repetition of signals in the Junction.

#### *Explanation of French terms.*

Passage. Feu vert = Line clear. Green light. — Passage avec attention. Feu jaune = Caution. Yellow light. — Arrêt. Feu rouge = Stop. Red light. — Passage. Feu vert = Line clear. Green light.

reduction to 40 km. (22 miles)/h. at the entrance to the Nord and Midi Stations.

A high speed over a short run of 3 600 m. (3 937 yards) with three stops in the case of certain trains is not of great interest.

## 2. Signalling. — Block system.

### Block sections.

#### Signalling.

The Junction will be equipped with colour light signals day and night.

14 trains an hour per line during the rush hours.

This is a very high number of trains on account of the various kinds of trains included : light trains, railcars, large railcars and heavy trains, with one or three stops according to circumstances.

Under such conditions, the intervals between trains have to be reduced to the minimum in order to retain a certain flexibility of operation.

With this object in view, owing to the low speed of the trains, the block

### JONCTION NORD - MIDI.

#### SCHEMA DE CANTONNEMENT DE BLOCK.

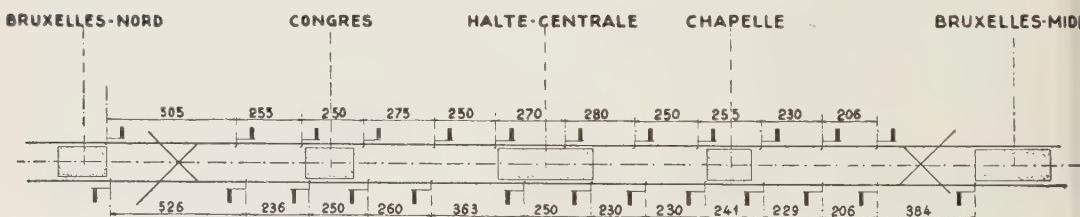


Fig. 13. — Block sections in the Junction.

The Belgian Railways are now using semaphore signals generally, but propose in the future for visibility reasons to adopt light signals as the electrification of the system progresses.

#### Block-system.

The density of the traffic in the Junction makes the use of the automatic block essential. The method chosen is the open track block-system, each train being protected by the previous signal without a « buffer » section (fig. 12).

#### Block sections.

The present provisions are based on

sections had to be fixed between 200 and 300 m. (218 and 328 yards) (fig. 13). To obtain the full benefit of such an arrangement, it was also necessary to arrange for the repetition of the previous signal at each signal (fig. 12).

This is a derogatory measure as the usual Belgian regulations prescribe that the distance at which the signals are repeated must be at least 800 m. (875 yards) when the speed is less than or equal to 100 km. (62 miles)/h.

It should be noted that in principle only passenger trains run through the Junction, which has made it possible to

agree to short distance repetition without any risk. If goods trains had to run through, their speed should be determined by the braking possibilities. The block section in this way makes it possible to let trains pass at intervals of 2 1/2 to 4 minutes according to the nature of the trains succeeding one another.

#### **Passing signals at danger.**

Although the final regulations have not yet been decided, it is probable that it will be permissible to run past signals at danger without any other formality than stopping the train first of all before the signal.

This also is a derogatory measure since the usual Belgian regulations lay down not only that the train must stop before passing the signal, but that it must not proceed until a written order has been handed to the driver.

After running past a signal at danger, the driver is allowed to continue with caution, known as «running on sight» over two sections in turn before resuming normal running speed if the signals are at line clear.

Finally in order to increase safety when running on sight, the tunnel will be lighted.

#### **Central Halt.**

The signals giving entry to the Central Halt cannot be run past as described above, as two trains cannot be allowed together on the same platform line.

The length of the platforms is not sufficient for two long trains, so there would be a risk that one train was only partly alongside the platform, which cannot be allowed.

The presence of two trains together at the platform is also a drawback from the points of view of clearing the passengers through the stairways, and of giving particulars of trains to the public.

The signals giving entry to the Central Halt can only be run past at danger when the train occupying the section pulls away from the platform.

For succession reasons, the departure signals could not be sited at the ends of the platforms. In order to be able to bring long trains up to the platforms, these signals can be run past at danger, but the regulations concerning this point have not yet been decided.

#### *3. Haulage conditions.*

Though in the future, a relatively far-off future, it is hoped that nearly all the traffic through the Junction will be completely electrified, it is however certain that for many years to come steam trains will be run through it.

The passing of heavy steam traffic through a 1 900 m. (2 078 yards) long tunnel gives rise to serious ventilation problems, as satisfactory removal of the smoke is essential not only from the hygienic point of view, but also as regards the visibility of the signals.

In order to decrease the emission of steam in the tunnel and facilitate ventilation, it has been decided that an electric locomotive shall be coupled to all the trains running through the Junction. This locomotive will haul the train, the steam locomotive having nothing to do except for a short distance on starting (some 30 m. = 33 yards) so that apart from this it will run with the regulator shut.

The addition of an electric locomotive (type BB, weight 80 t., 2 200 H.P.) to steam trains involves electrifying the Nord and Midi Stations installations, as well as the lines through the Junction as soon as the latter is put into service.

The addition of an electric locomotive to every steam train passing through the Junction will be a very heavy burden on the operation of the Nord and Midi Stations for an indefinite period.

In order to avoid shunting the electric locomotives during rush hours in the stations, it has been decided to put them at the head of the trains in one direction of running and at the tail in the opposite direction.

Thus the steam trains will have an electric locomotive at the head when running south to north, and at their tail when running north to south.

In both stations, the dead end lines make it easy to carry out the necessary shunting movements when coupling up or removing the electric locomotives.

When running with the locomotive at the tail, it is necessary to have some connection between the drivers of the two engines when starting. All that will be done is the linking up of the electric locomotive to the brake pipe. On starting a depression in this pipe made by the driver of the other locomotive will be seen by the driver of the electric locomotive.

To prevent the electric locomotive at the end of a train continuing to push a train when the brakes are suddenly applied, these locomotives will be fitted with a device to cut the traction current when the brakes are suddenly applied (Switch control).

#### 4. *Journey times.*

The time taken to cover the distance between Brussels Midi and Brussels Nord varies from 7 to 11 minutes according to the kind of train.

### IV. — Ventilation.

The investigation and installation of the ventilation equipment in the 1 900 m. of tunnel are the responsibility entirely of the engineers of the National Office of the Junction. Here we will only describe the essential characteristics of the problem and its solution.

#### 1. *The ventilation problem.*

The lines in the tunnel will be run over by steam trains, electric railcars or trains and railcars. Steam locomotives will only be used for starting up, so that the emission of fumes (gas and steam) is limited to the stopping points in the Central Halt and Congress, as well as stops by signals.

The main problem is to get rid of the CO and CO<sub>2</sub> gases and the steam emitted.

This has three objects in view : hygiene, the comfort of the passengers, and the visibility of the signals.

#### 2. *Ventilation solutions adopted.*

The solutions to be adopted depend upon the nature of the ventilation equipment.

The comfort of the public requires thorough ventilation, without any draughts, in a station like the Central Halt.

On the other hand out in the tunnel where the trains run with the windows

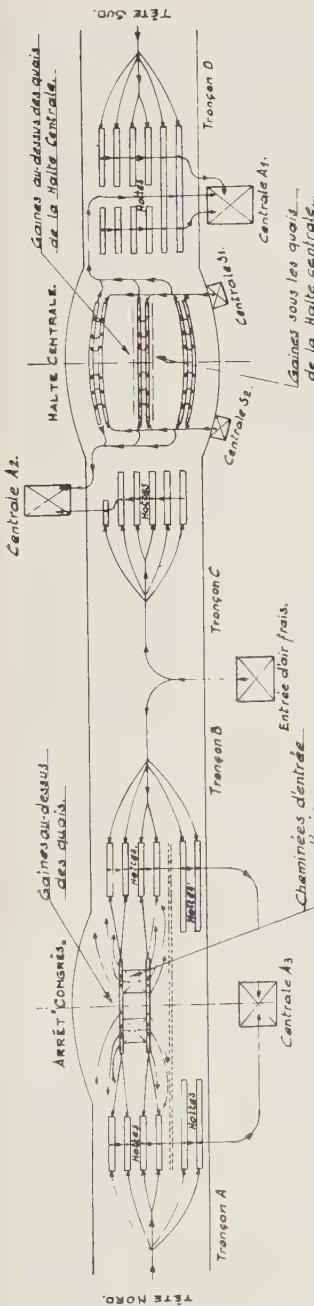


Fig. 14. — Ventilation of the Junction. — Diagram of the principle used.

*Explanation of French terms.*

Tête nord = north end. — Tronçon = Section. — hottes = ventilating hoods. — Arrêt Congrès = Congress stopping point. Gaines au-dessus des quais = Ducts above the platforms. — Cheminées d'entrée d'air = Funnel through which fresh air is drawn. — Entrée d'air frais = Entry of fresh air. — Gaines sous les quais de la Halle Centrale = Ducts under the platforms of the Central Halt. — Gaines au-dessus des quais de la Halle centrale = Ducts above the platforms of the Central Halt. — Tête sud = South end.

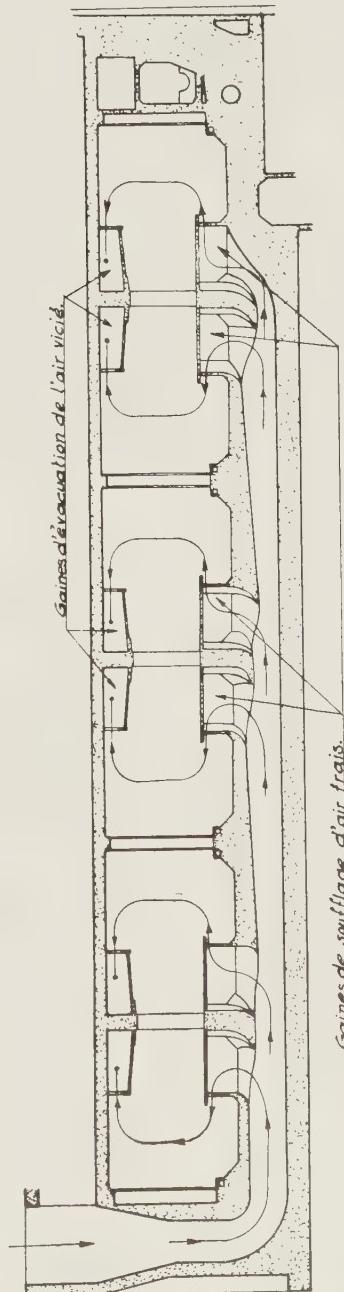


Fig. 15. — Central Halt. — Section = Transversal ventilation.

*Explanation of French terms.*

Gaines d'évacuation de l'air vicié = Ducts for drawing off used air. — Gaines de soufflage d'air frais = Ducts for blowing in fresh air.

shut, ventilation can be limited to what is sufficient for public hygiene and the visibility of the signals.

Consequently four different types of equipment were decided upon :

Out in the tunnel = longitudinal ventilation;

Central Halt = transversal ventilation;

Congress stopping point = separate transversal ventilation;

At the stopping places in the station = extractor hoods which remove the fumes immediately.

Fig. 14 shows diagrammatically the general ventilation of the tunnel.

case of the longitudinal ventilation of the central sections B and C of the tunnel, fresh air being drawn in through a huge opening about the middle of the tunnel.

The used air from Section C is evacuated through the hoods north of the Central Halt and the ventilators of the ventilation station A<sub>2</sub>.

#### **Central Halt (fig. 14 and 15).**

Transversal ventilation is installed over the whole length of the platforms in the Central Halt so that there are no draughts on the passengers on the platforms.

Two fans draw in fresh air through

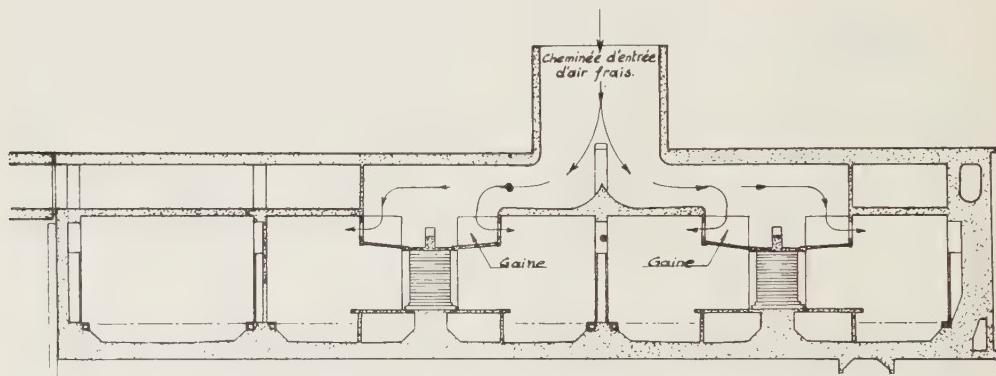


Fig. 16. — Congress Halt. — Ventilation (cross section).

#### *Explanation of French terms.*

*Cheminée d'entrée d'air frais* = Funnel for drawing in fresh air. — *Gaine* = Duct.

#### **In the tunnel.**

In the sections A and D of the tunnel, longitudinal ventilation is assured by drawing in fresh air at the ends of the tunnel and evacuating the used air by means of the hoods north of the Congress stopping point and south of the Central Halt by means of the ventilators of the ventilating station A<sub>1</sub> and A<sub>3</sub>.

The same processus takes place in the

casings under the platforms (fig. 15) while two suction points A<sub>1</sub> and A<sub>2</sub> get rid of the used air through shafts in the platforms.

#### **Congress stopping point.**

For this less important stopping point independent longitudinal ventilation was considered sufficient, limited to the two platforms (fig. 16). The third outlet of

the tunnel where there is no platform will be cut off from the other two by a partition.

### 3. Certain technical characteristics.

*Dilution of noxious gases* : the ventilation is planned to change the air fast enough to ensure that the maximum CO<sub>2</sub> and CO content will be 15/10 000 and 4/10 000 respectively.

*Steam* : the calculations show that under certain unfavourable conditions fog may be produced.

*Output* : the output based on the content of noxious gases which must not be exceeded amounts to :

290 m<sup>3</sup> (379 cubic yards) sec. in section A;  
160 m<sup>3</sup> (209      ) sec. in section B;  
220 m<sup>3</sup> (287      ) sec. in section C;  
300 m<sup>3</sup> (392      ) sec. in section D;

screw type, rotating at low speed, with a large diameter impeller. They are driven by electric motors. Regulation is done by setting the vanes when stopped and the gearbox.

### V. — Regulation of the traffic. — Announcing the trains to the staff and to the public.

#### 1. General organisation.

##### Lines to Brussels.

Traffic regulation as far as the signal boxes at the entry to the Nord and Midi Stations is assured by the usual dispatching system.

##### Station traffic.

The traffic in each station will be directed by a « traffic regulator » who with his telephone operators will be

Number of ventilators and power.

	A1	S1	S2	A2	A3
Number of ventilators in normal service.	2 + 1	1	1	2 + 1	2
Number of ventilators (spare) . . . .	1 + 1	1	1	1 + 1	1
Power of the installation in H.P. . . .	3 × 35.5 2 × 35.5	2 × 35.5	2 × 35.5	3 × 35.5 2 × 35.5	3 × 7.5

The output of 150 m<sup>3</sup> (196 cubic yards) sec. in the case of the transversal ventilation of the Central Halt was planned so as to obtain a complete change of air eight times an hour.

### 4. Ventilators.

The ventilators selected are of the

located in the main signal box, close to the signal staff. The « traffic regulator » will have complete authority as regards train movements and shunting in the station. He also is responsible, if anything untoward occurs, for altering the prescribed sequence of trains through the Junction.

### Traffic through the Junction.

The Junction must be so operated as to keep all the trains running in the three outlets exactly as laid down. A train can only pass through a different outlet under very exceptional circumstances.

Any alteration in the route leads to considerable inconvenience being caused to passengers at the Central Halt and intermediate stopping points, as it means

### 2. Collaboration between the Operating Department and the Electrical Services.

The tunnel haulage conditions make it essential that the Junction as well as the Nord and Midi Stations be electrified throughout as soon as completed.

As soon as this has been done, and even more so when the lines ending at Brussels have been electrified, any defects in the electrical installations and the

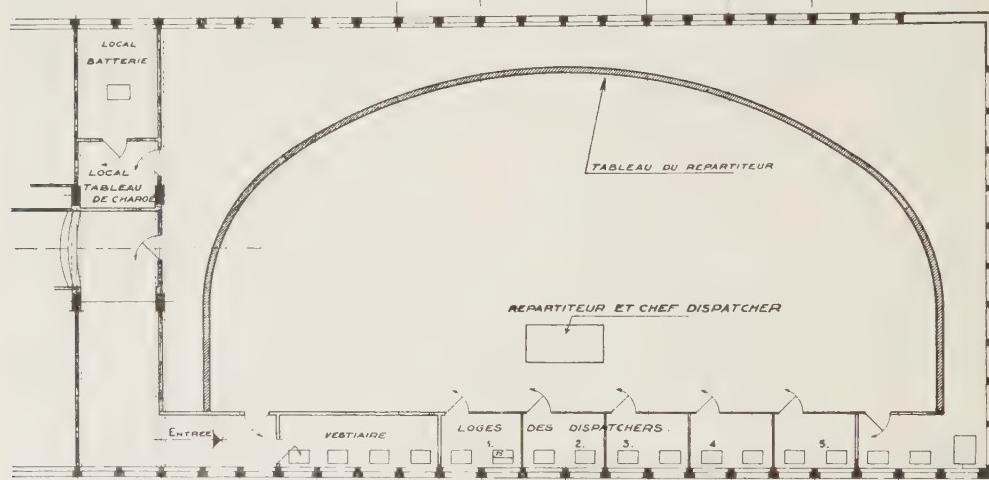


Fig. 17. — Junction controller and dispatching.

#### *Explanation of French terms.*

Local batterie = Battery house. — Local tableau de charge = Switchboard cabin. — Tableau du répartiteur = Controller's map. — Répartiteur et chef dispatcher = Controller and chief dispatcher. — Entrée = Entry. — Vestiaire = cloakroom. — Loges des dispatchers = Dispatchers offices.

that they have to change from one platform to another very quickly.

In principle such a change can only be permitted when one line of the Junction is out of service.

It may be mentioned that if there is any obstruction, it is not proposed to organise single track running, but the traffic will be redistributed over the other lines still available.

maintenance will affect the operation of the Junction.

Close collaboration is essential between the chief dispatcher in charge of the traffic throughout the Brussels area and the specialist official (controller) in charge of the electrical installations.

The chief dispatcher and the controller will work side by side in one place (fig. 17) in which are grouped together the dis-

patching services and the general plan of the controller.

This plan shows the part of all the lines in the Brussels area diagrammatically (the Liege line however is shown practically in its entirety).

This plan gives also a complete picture of the electrical supply to this system :

a) Control and distance control of the electrical substations in the distribution area, viz the two Brussels substations (Nord and Midi) and the three substations which will be built when electrifying the line to Liege (Louvain-Landen-Voroux).

b) Control of the old substation which has supplied the Brussels Antwerp line since 1935 (Haren).

It should be remembered that the electrified system is supplied with 3 000 volts direct current and the new electrical substations are supplied with 30 000 to 70 000 V. alternating current.

Each station includes a certain number of 3 000 kW. transformer-rectifier groups.

c) Control and distance control of the block sections on the open line including circuit breakers.

d) Control and distance control of the block sections in the Junction (three sections in the Nord and three in the Midi) including circuit breakers and cutouts.

In addition to these operations, the controller gives the orders for operating the circuit breakers under load on open track which are operated from the block section posts.

The controller has nothing to do with the shunting of section cutouts (under tension) which are worked by hand to isolate local lines in the stations.

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The whole of the Dispatching-Controlling Department will be housed in offices in the Brussels regional group, but the exact site has not yet been decided.

### 3. *Service announcements.*

In principle, although alterations in the use of the three outlets must be considered as exceptional, it cannot be expected that there will never have to be any alteration in the sequence of trains arranged, as the local regulators have to take whatever steps circumstances make necessary.

It is therefore essential to announce the trains between the outer stations of the Junction.

The system in view includes a tele-printer device for each line of the Junction.

Each of the end stations will have a transmitting and recording machine for each outlet of the Junction.

At the moment of departure, the Controller will give the time of departure and the number of the train. This will be recorded simultaneously on the tape at the transmitting machine at the departure station and on the tape of the recording machine at the arrival station.

This simple system has the advantage of leaving a check record. However the choice of the system depends upon the solution to be adopted for a much more complicated problem, namely announcing the trains to the public.

### 4. *Announcements to the public.*

The Belgian public is accustomed to finding on the platforms an indication of the departure time, the destination and

kind of train expected. In the Nord and Midi Stations, there is no special difficulty in giving these indications, whether they are written up on the platform by an employee or given by long distance control from a signal box.

At the Central Halt however the following special difficulties have to be

politan line owing to the great diversity of destinations.

In the case of the 790 trains running through the Junction, 85 different destinations have to be announced. Consequently each equipment on the platform must be able to show about 50 destinations.



Fig. 18. — Brussels Nord Station.  
New station. Waiting rooms on the platforms.

taken into account when selecting the method to be used :

- as the platforms are curved, the announcements have to be given at several different places, at least three per line;
- there may be less than 3 minutes interval between trains which makes it impossible to write out the necessary information by hand.

It is therefore essential in this case to use long distance operated announcements.

The problem is especially difficult and quite different from those on a metro-

It has been considered having an employee on each platform in charge of the announcements who will have at his disposal a teleprinter for each line to pick up the service announcements sent out.

At the present time a less costly solution from the point of view of staff is under consideration, which will make it possible to combine the service and public announcements.

This is the system of announcing trains by the departure station (Nord or Midi), the warning travelling in front of the

train and dying out behind it, the system used on the London Metropolitan under the name of « train-describer ».

This system will also solve the problem of announcing the trains at the Congress and la Chapelle stopping points.

Whatever the system adopted, its application will still require very careful planning.

\*\*\*

information bureau, bookstall, post office, telegraphs, telephones, hairdresser, florist, Red Cross, customs, etc.

At the two main stations there is a restaurant and buffet open to the public without their having to go onto the platforms.

There is also a buffet on the platforms, as well as waiting rooms and lavatories.



Fig. 19. — Brussels Nord Station.  
Public and service telephone booths on the platforms.

### CHAPTER III. — THE STATIONS.

#### I. — General characteristics.

Though the Central Halt is designed above all for outer suburban traffic, the Nord and Midi Stations are equipped to deal with traffic from all distances.

#### 1. Reception buildings. — Installations for the use of the public.

The public will find all the usual facilities : booking and luggage offices,

#### 2. Corridors and platforms.

The circulation of the public in the station has been carefully planned, either by completely separating the arrivals and departures (Nord) or by the use of very wide spaces (Midi).

The platforms are under cover for the whole of their length. Spacious waiting rooms (fig. 18), which are heated in winter, enable passengers to shelter whilst awaiting their trains.

Seats, draught partitions, clocks, and telephone booths (fig. 19) complete the amenities.

Fluorescent tube lighting is the general rule in the corridors. A trial lighting of the platforms in the same way is being made at the Nord.

### *3. Handling of luggage and parcels.*

Luggage and parcels are handled at the station between the offices and the platforms by routes not open to the public.

The narrow space available made it impossible to have special platforms for luggage.

There is a service lift at each end of the passenger platforms linking them up with the corridors and underground handling offices.

### *4. Telephones and loud-speakers.*

Automatic service telephones are available for the use of the staff on every platform.

The corridors, waiting rooms and platforms will be equipped with many loudspeakers of low power to keep the public advised of any changes in the services.

Soundproof booths will make it possible to transmit the necessary information, either from the platforms or from the signal boxes.

### *5. Station offices.*

The offices for the use of the station staff show the care that has been taken to make the place of work hygienic, comfortable and attractive. The choice of materials and colours, lighting and air conditioning are all inspired by this object.

### *6. Booking offices.*

The arrangement of the booking offices has been very carefully studied, and they are deserving of a brief description.

The Belgian National Railways propose to make general the use of a new ticket printing machine in all their large stations. This patented machine, invented by a Belgian, required several years of patient work to perfect.

The machine in question has the following excellent characteristics :

- distribution is as fast as that obtained with pigeon-holed tickets;
- small size and low weight;
- very robust;
- moderate cost;
- light plates, which are cheap, easily replaced and can even be reused;
- simplicity of operation.

The use of this new machine makes it possible :

1. To do away with the printing and storing of large quantities of printed tickets;
2. To simplify very considerably the accountancy, as the machine records the total for each ticket issued. It is only necessary to add up the total for each operator during his turn of service;
3. The absence of pre-printed tickets does away with keeping of ticket accounts and the formalities required when two employees are working at the same office.

Figs. 20 and 21 show two views of the booking offices as planned for the new Brussels station (Midi).

In these booking offices the operators may sit at work.

Conversation between the public and

the employee take place by means of a « Hygiaphone » device which is germ-proof.

4. Statistical records of the various categories of tickets sold, in particular cheap fares, will not present any difficulty.

mechanical interlocking between the points, route and signal.

The routes are divided. Operating of the route lever ensures in turn : control of the points levers and locking of the route. The release of the signals also



(Photo S. N. C. F. B.)

Fig. 20. — Booking office equipped with ticket printing machine, and « Hygiaphone » (Brussels Midi). Seen from the « public » side.

On the left, in the foreground : the machine.

On the right, in the background : one of the cases of printing blocks.

### 7. Signalling.

The signalling of the two stations will be entirely by light signals both day and night.

The signal boxes are of the most up-to-date pattern used on the Belgian railways.

They are electric signal boxes, retaining

results in the supplementary operation of certain route levers.

The block system at the station approaches will be either entirely automatic or semi-automatic, the section being normally deblocked.

Announcement of the block has been suppressed and replaced by information

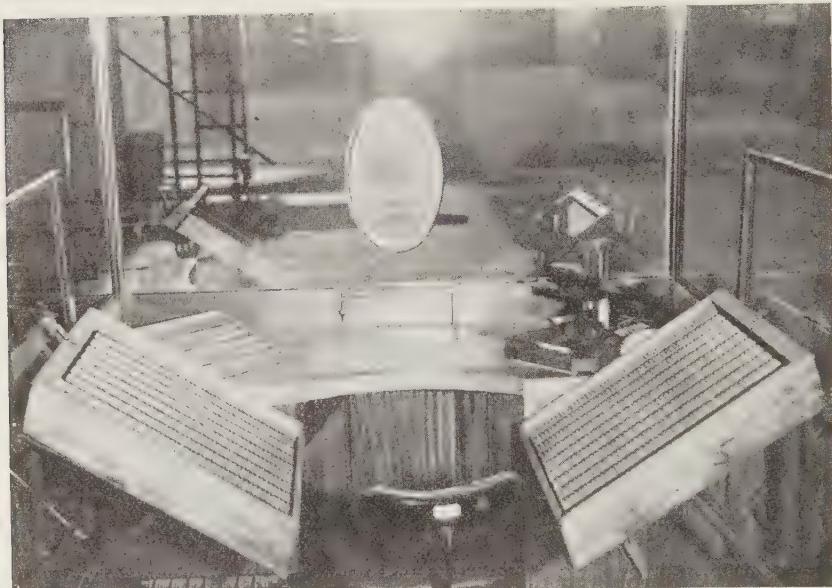
concerning train movements recorded on a needle-dial.

## II. — Organisation of the work.

If the Nord-Midi Junction properly so called is an interesting achievement from

old stations, whilst in no way interfering with the normal capacity of the installations.

It was not possible to avoid using the two stations whilst the work was in process. On the Midi side there was in



(Photo S. N. C. F. B.)

Fig. 21. — Booking office equipped with ticket printing machine (Brussels Midi).  
Seen from the clerks side.

As at February 1949. The lighting for the cases of printing blocks not yet fitted.

*In the foreground : the two cases of blocks each holding 500.*

*In the background to the right : the machine.*

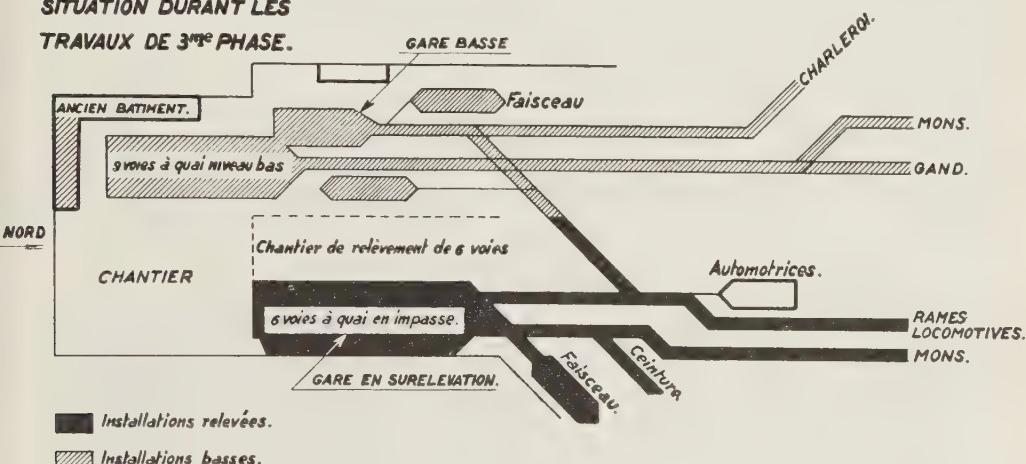
*In the background to the left : the till.*

the civil engineering point of view, the construction of the two new stations, for which the National Railway Company is responsible, has given rise to some tricky problems.

It was necessary to build two new stations at a higher level, on the site of the

fact no other station capable of absorbing the traffic. On the Nord side, although there is the Schaerbeek Station with its very extensive equipment, its distance from the centre of the town made it impossible to use it as a temporary station instead of the Nord.

**BRUXELLES-MIDI**  
**SITUATION DURANT LES**  
**TRAVAUX DE 3<sup>e</sup> PHASE.**



**APRES MISE EN EXPLOITATION  
DES INSTALLATIONS CONS-  
TRUITES EN 3<sup>e</sup> PHASE.**

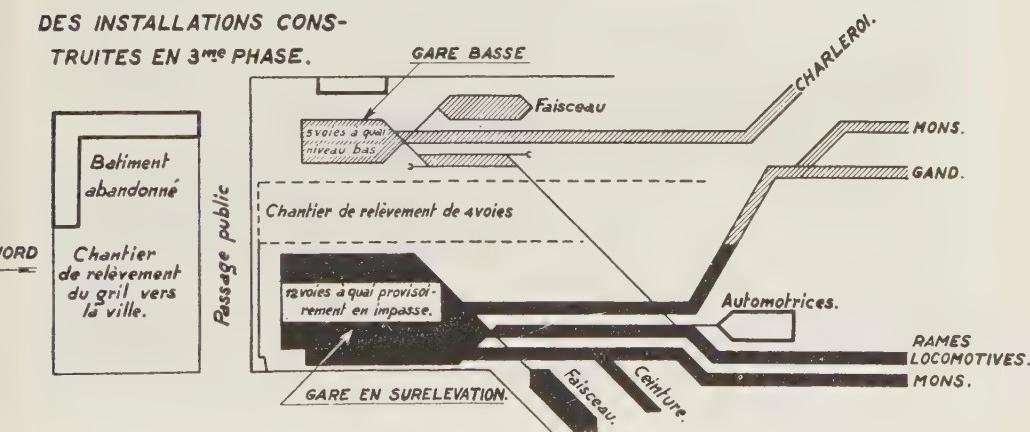


Fig. 22. — Brussels Midi.

Diagram of the installations during the work carried out in the 3rd phase and after this had been completed.

We cannot describe in detail the organisation of the work, but will briefly detail the different stages :

— first of all a few lines on one side of the old station were put out of service. This involved making certain preparatory ar-

rangements intended to make good the reduced capacity of the station. This work naturally took place on the opposite side of the station;  
— then a certain number of lines were built at the new level in the space thus rendered available, as well as the corresponding platforms and buildings;

- the new lines were then opened to traffic, which freed a further series of the old lines;
- new lines were again built at the higher level, and so on.

These successive stages numbered five in the case of the Midi and six in the case of the Nord (with many intermediate stages).

never covered less than 4 lines, and generally six.

In the case of the Nord, on the contrary, the amount of room available made it necessary to limit certain stages to a single line.

The preliminary stages involving a considerable amount of work on adjoining lines and adjoining installations, such as



(Photo C. A. M.)

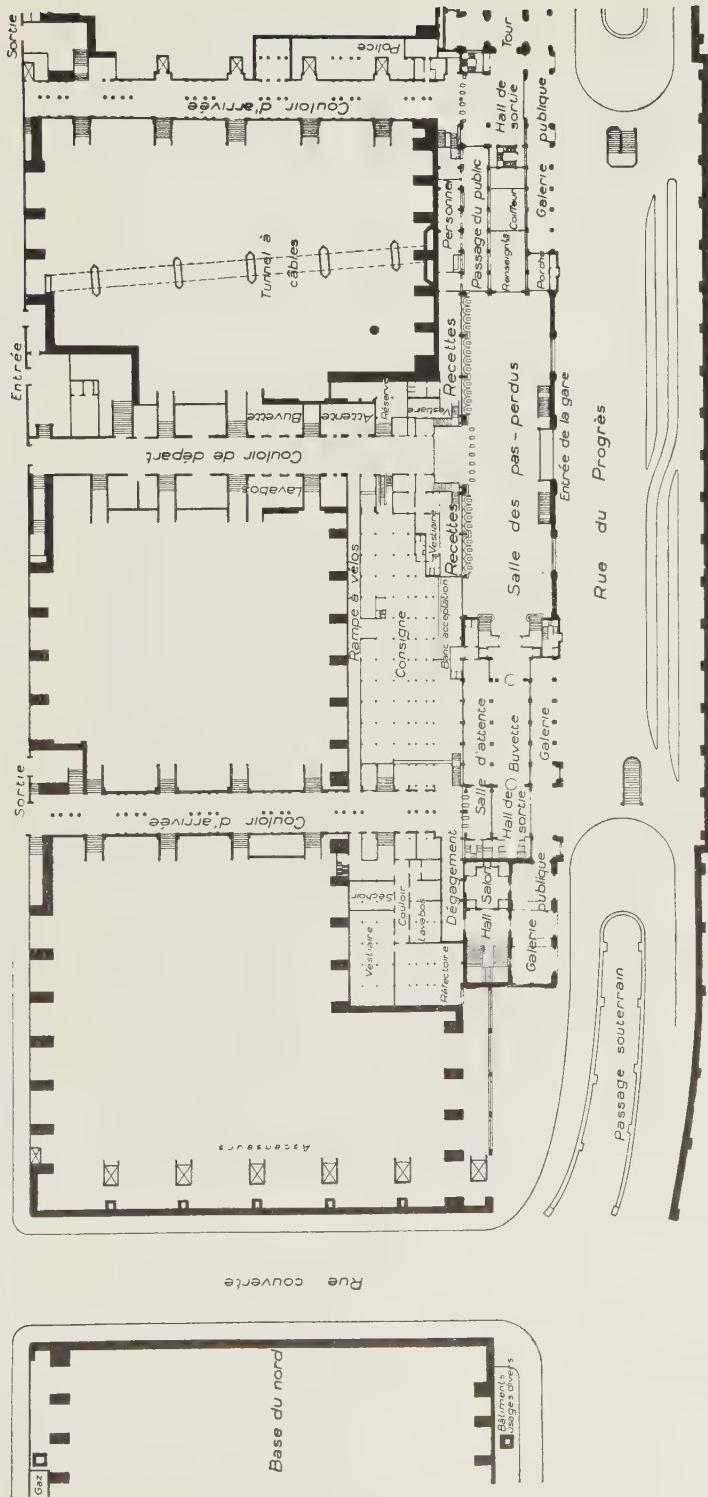
Fig. 23. — Brussels Nord. — Model of the station.  
The esplanade will be noticed which enables vehicles and trams to leave their passengers on the intermediate level between the road and the platforms.

The larger amount of room available at the Midi made it possible to free a greater number of lines than at the Nord, so that all the stages covered a greater amount of ground.

In the case of the Midi, each stage

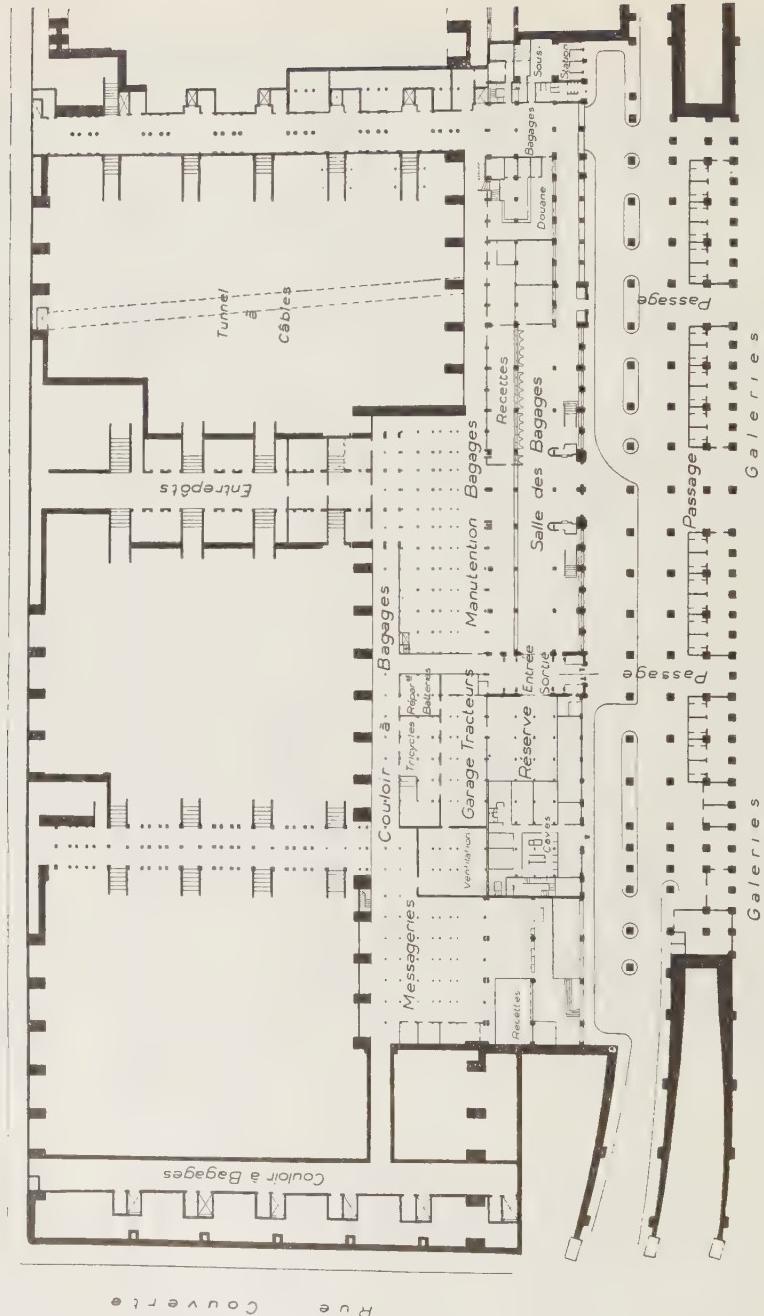
sidings, etc., had to be completed before the real work of raising the level of the stations could be started.

Each stage involved the carrying out of certain provisional work on the track, signals, lighting, etc. Each involved



(Cliché Technique des Travaux.)

Fig. 24.— Brussels Nord.— Plan of the esplanade level (level + 4).



(Cliché Technique des Travaux.)

Fig. 25. — Brussels Nord. — Plan of the ground floor (Street level : 0).

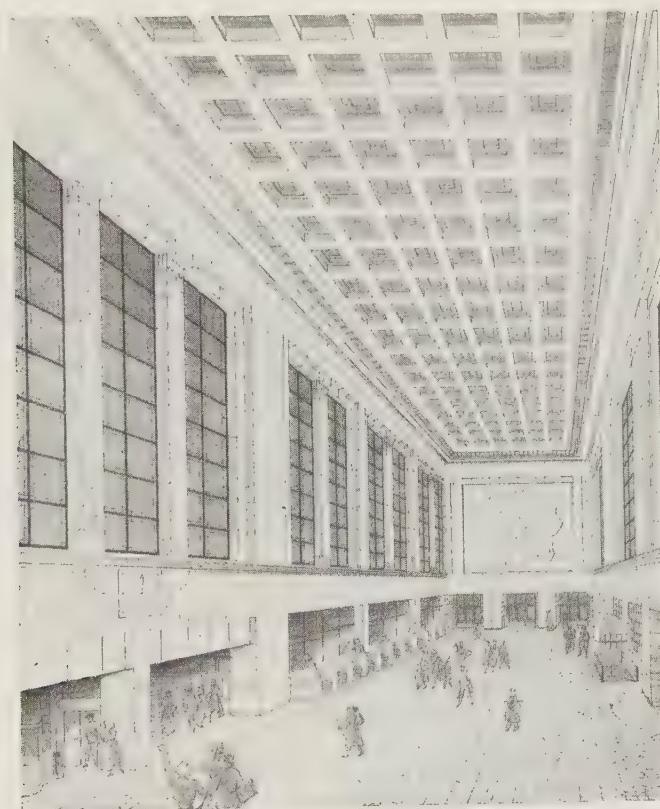
problems as regards the issuing of tickets, movement of passengers in the station, announcements to the public, the circulation of the tram services adjoining the stations.

Fig. 22 shows for example the changes in the Midi station when the third stage was completed (track).

### 1. General arrangement of the main station building.

The main building lies to one side of the raised up lines which are 7 m. (7.65 yards) above street level.

The originality of the design lies in the fact that the main parts of the building used by the public lie at an intermediate



(Cliché Technique des Travaux.)

Fig. 26. — Brussels Nord. — View of the proposed booking hall (on the esplanade level).

### III. — NORD STATION.

We will content ourselves with outlining the essential characteristics, as the details can be learnt from the figures.

level (+ 4) between street level (taken as 0) and platform level (+ 8).

In front of the building is a very wide esplanade reached by two slopes (fig. 23)

which enables the trams and motor vehicles to deposit passengers at this intermediate level.

This reduces the amount passengers have to climb in the station to reach the platforms by half.

It must be noted that automobiles are not allowed to run on the esplanade (fig. 24) in order to prevent their inter-

level is reached by two stairways from the booking hall.

## 2. Corridors and platforms.

The corridors for passengers are so designed as to completely separate the departure and arrival traffic. The Departure corridor starts in the booking hall (fig. 24) at + 4 level.



Fig. 27. — Brussels Nord. — View of the platforms.

ference with the flow of passengers using the trams. The booking offices for places in the country as well as the other premises are grouped in and around a vast hall (figs. 24 and 26) (+ 4 level).

The booking offices for international services and season tickets are situated at street level (0) (fig. 25).

A road under the esplanade enables passengers to be deposited at these offices.

Two stairs and escalators connect the street level offices to the upper hall.

The restaurant which lies at platform

At each end of this corridor are the stairs to the platforms, one of the two flights of stairs being doubled by an escalator.

At each end of the building, still on the same level as the esplanade, an arrival corridor enables passengers to leave the station.

The three corridors are 8 m. (8.75 yards) wide and they all have outlets into a secondary road on the opposite side to the main building.

A small bookinghall with 5 guichets

deals with the issue of tickets on this side.

The platforms, which are 300 m. (328 yards) long and 8 m. wide, are covered in throughout their length by overhanging reinforced concrete roofs (fig. 27). The stairways are 3 m. (3.28 yards) wide.

### *3 Service installations.*

The handling of parcels and luggage is concentrated at street level. The transport of parcels between the handling depots and the platforms takes place along a luggage corridor at each end of the building.

Lifts (1 000 kgr. [2 204 lbs.] capacity) connect these to the platforms. The different installations, such as maintenance depots for tractors and trolleys used for luggage, cloakrooms, canteens, sanitary installations, offices, etc., are distributed amongst the street level and different stories.

The offices are sited in the tower (fig. 23).

The single signal box covering the two ladder tracks for north and south is also sited in the building (fig. 28).

Service lifts connect the different stories.

### *4. Critical remarks.*

As we have already said, a work which takes a great many years to complete with many interruptions of various lengths, is sure to have certain weak points, especially when the solutions adopted cannot be based solely on operating considerations.

Thus, from the railway point of view certain arrangements are unfortunate, and in particular :

- the location of the installations used by the public on two different levels;
- the fact that the departure corridor could not be sited centrally in relation to the platforms (115 m. [125 yards] on one side and 185 m. [202 yards] on the other), so that the arrival corridors are unequally used;



Fig. 28. — Brussels Nord. — New signal box. Interior. The frames are only partly in use for controlling the raised installations. The windows looking out on the line can be seen on the left. The group of frames in the background control the ladder track into the Junction, whilst those in the foreground cover the Nord ladder track.

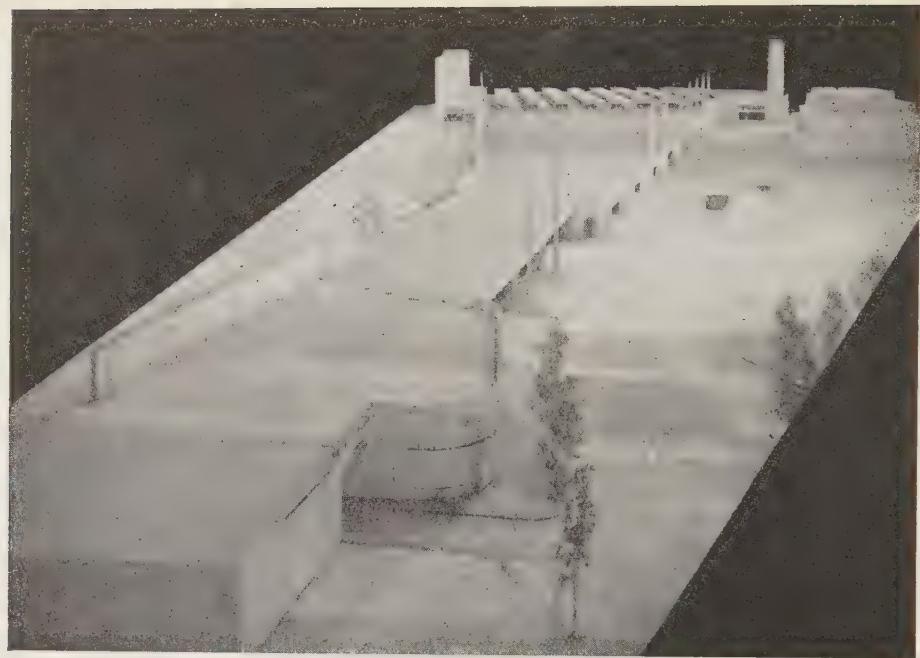


Fig. 29. — Brussels Midi. — Model of the entry viaduct.



Fig. 30. — Brussels Midi. — Model showing the station.  
*On the left under the dome : the main entrance.*  
*In the centre under the pent roof : exit from the side corridor.*

— the narrowness of the platforms which are only 8 m. (8.74 yards) wide including many 3.50 m. (3.82 yards) obstructions, such as waiting rooms, entrance to stairways, etc.

It would have been desirable to make

the platforms will not take place fast enough.

The end platforms serving the outer lines Nos. 1 and 12 are only 4.25 m. (4.64 yards) wide with 1.50 (1.64 yards) stairways, although one of them has to

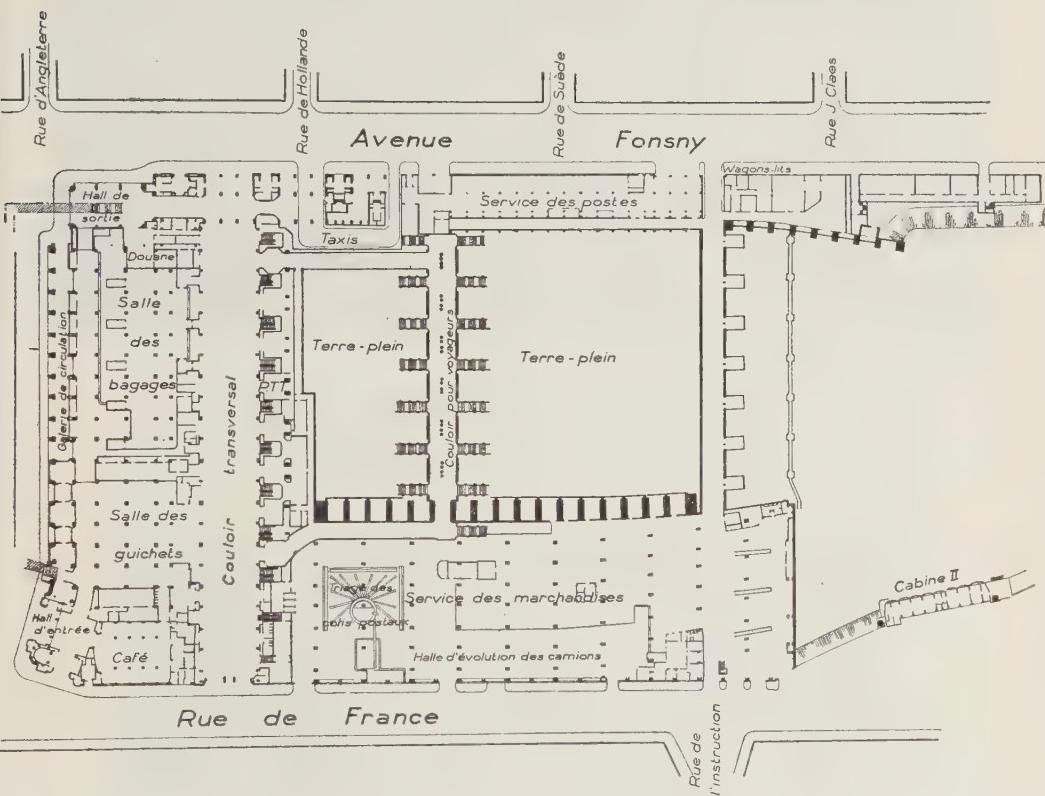


Fig. 31. — Brussels Midi. — Plan of the ground floor.

them at least 10 m. (10.93 yards) wide and better still 12 m. (13 yards).

The arrival corridor on the town side is only reached by a single stairway from each platform. As passengers tend to make use of the nearest exit to the town, it is to be feared that this stairway will prove insufficient and the clearance of

deal with the very important Antwerp-Charleroi traffic.

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#### IV. — Midi Station.

Nearly all the station building, and in particular the booking hall is sited under the tracks (figs. 29 and 30).

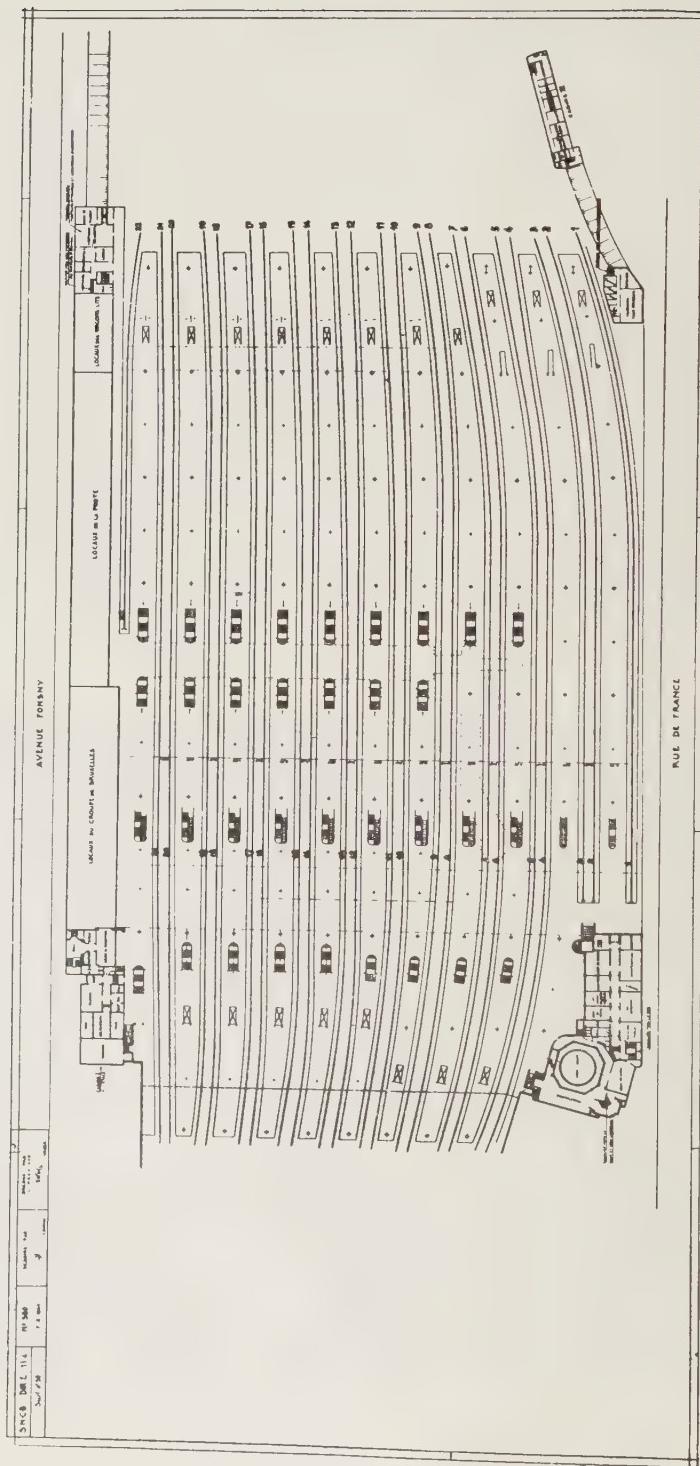


Fig. 32.—Brussels Midi.—Plan of the platforms.  
On the left, the group of offices for the station master and his department.



(Photo S. N. C. F. B.)

Fig. 33. — Brussels Midi. — View of the platforms on the upper station.  
In the background the walls carrying the old hall of the lower station. On the right the wooden  
passage connecting the upper and lower stations.



(Photo S. N. C. F. B.)

Fig. 34. — Brussels Midi. — View of the partially completed booking hall  
(February 1949).

### 1. Public installations.

As the lines have only been raised 6 m. (6.56 yards) above the old level, all the places used by the public lie at street level.

The general plan (fig. 31) is the grouping of all the offices on both sides of a huge corridor 20 m. (21.87 yards) wide,

corridor to reach the main corridor by two slopes.

The booking hall consists of two rows of 12 guichets arranged face to face 40 m. (44 yards) apart. (fig. 31).

Figs. 34 and 35 show two views of the booking hall which is partially completed.

Under the ladder track leading to the



(Photo S. N. C. F. B.)

Fig. 35. — Brussels Midi. — New booking hall.  
View of one of the lines of booking offices now partly completed (February 1949).

running through the station, and giving access to the two roads on either side of the station.

The stairways to the platforms are at each end of this corridor. On the south end, each stairway consists of a fixed part and an escalator.

A second corridor parallel to the former (10 m. [10.93 yards] wide) at a slightly higher level is used by passengers changing trains. Passengers arriving can leave this

junction there is first of all a covered-in roadway with tram stops, and then a trapezoidal building intended to serve as a bus station.

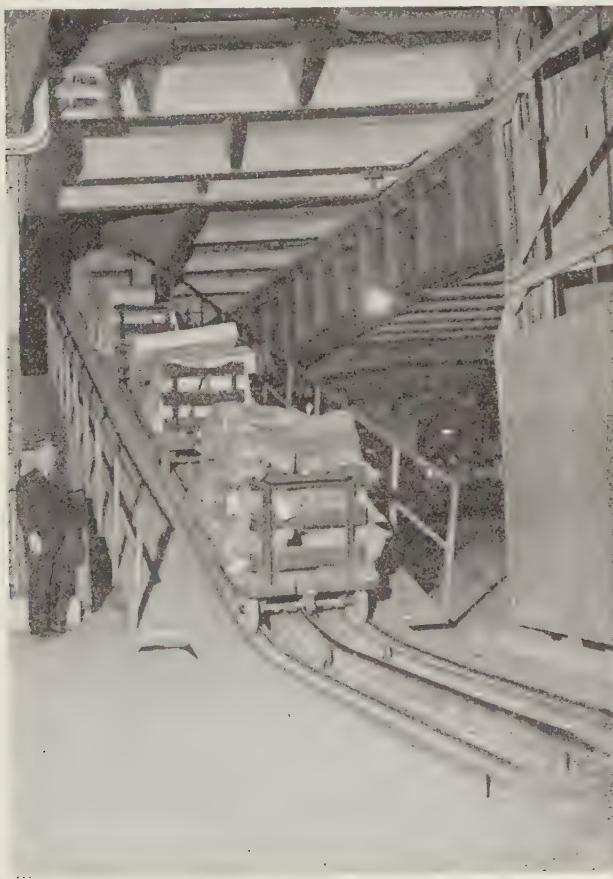
The safety of the passengers between the station and the trams or buses is completely assured thanks to the public subways under the roads, one of which comes out in the booking hall, and the other near one of the exits from the main corridor.

The platforms which are 300 m. (328 yards) long and 9 m. (9.84 yards) wide are protected by metal overhanging roofs.

Fig. 33 shows a view of the platforms which are only partly completed. The

southern side, the raising up of the lines has made it possible to construct a wide road passage-way under them.

Tubular lighting will be used throughout.



(Photo Nizet.)

Fig. 36. — Brussels Midi. — Inclines carrying the trucks up towards the platforms.

setting back of the station has made it possible to improve the town traffic, thanks to the making of the covered-in roadway beside the Junction. On the

## 2. Service installations.

The handling of luggage and the handling of postal packages and express goods will be dealt with separately.

The consigning, accepting and delivery of luggage is concentrated at street level close to the luggage depot (fig. 31).

So that the movement of the trucks will be separated from the passengers, a handling office has been arranged below ground. Lifts (capacity 2 000 kgr. [4 409 lbs.], in certain cases : 3 200 kgr. [7 054 lbs.]) connect this office to the north end of the platforms. Some of these lifts had to be placed out of line in order to avoid the main hall, and do not stop at street level.

As we have already mentioned the Midi station is equipped with a local parcels depot which will accept postal parcels and express goods and deals with door to door services for parcels and luggage.

The necessary installations are situated in a hall of some 10 000 m<sup>2</sup> (11 960 square yards) area.

This hall has two characteristic features :

- a mechanical plant for sorting the postal parcels for packing in the mail bags. This equipment easily handles 5 000 parcels an hour;
- inclines to the shunting platforms for the express goods trains. These inclines which are fitted with endless chains with fingers enable the trucks to be taken up or down between the hall and the platform. The output of this plant is about 200 to 250 trucks an hour (Fig. 36). The trucks are pulled along by the fingers which fit into a special attachment under the floors.

A luggage and parcels subway equipped with lifts connects this hall to the south ends of the platforms (fig. 31).

To convey the luggage from the underground depot to the south lifts, a slope running under the main passenger corridor links this depot to the goods hall.

The goods offices are arranged in the

hall itself. The offices of station employees as well as the cloakrooms and canteen are on the same level as the platforms, so that artificial lighting is unnecessary (fig. 32).

In view of the fact that trains are reformed in the Midi Station, it is necessary to provide for a lot of shunting. Consequently it was considered better to have a separate signal box for each ladder track.

The most important signal box, on the South side, has been in service since 1940. With its 13 frames, 26 m. (28 yards) in length in all, it is the largest on the system (figs. 37 and 38).

### *3. Criticisms.*

Various arrangements are unfortunate, in particular :

- siting the booking hall under the lines, which necessitated having 12 massive pillars (Fig. 31), and involves artificial lighting all the time. It is very expensive to build a booking hall in this way, as special precautions have to be made to make it watertight and soundproof. Maintenance is likely to be difficult;
- siting the main corridor to one side instead of centrally in relation to the platforms. The stairways from this corridor come out on the platform at 55 m. (60 yards) from the north end and 190 m. (207 yards) from the south end.

The original arrangement was to have a 2 m. (2.18 yards) wide stairway on the south side for the use of the passengers on this 190 m. length of platform (the escalator being reserved for passengers boarding trains).

This arrangement proved insufficient so that a second corridor had to be made connecting with the side corridor.

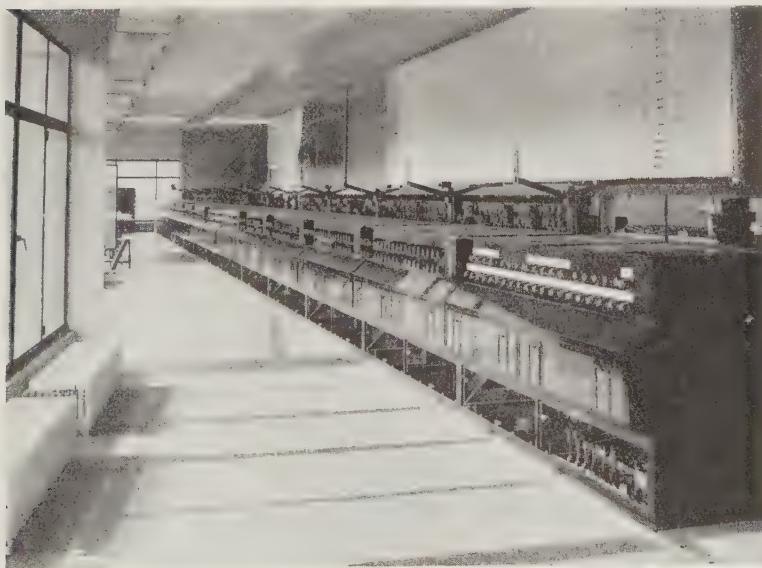
The station as a whole will prove convenient for passengers.

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(Photo S. N. C. F. B.)

Fig. 37. — Brussels Midi. — South signal box. Side facing the track.



(Photo S. N. C. F. B.)

Fig. 38. — Brussels Midi. — South signal box. Interior view  
of the signalmen's floor.

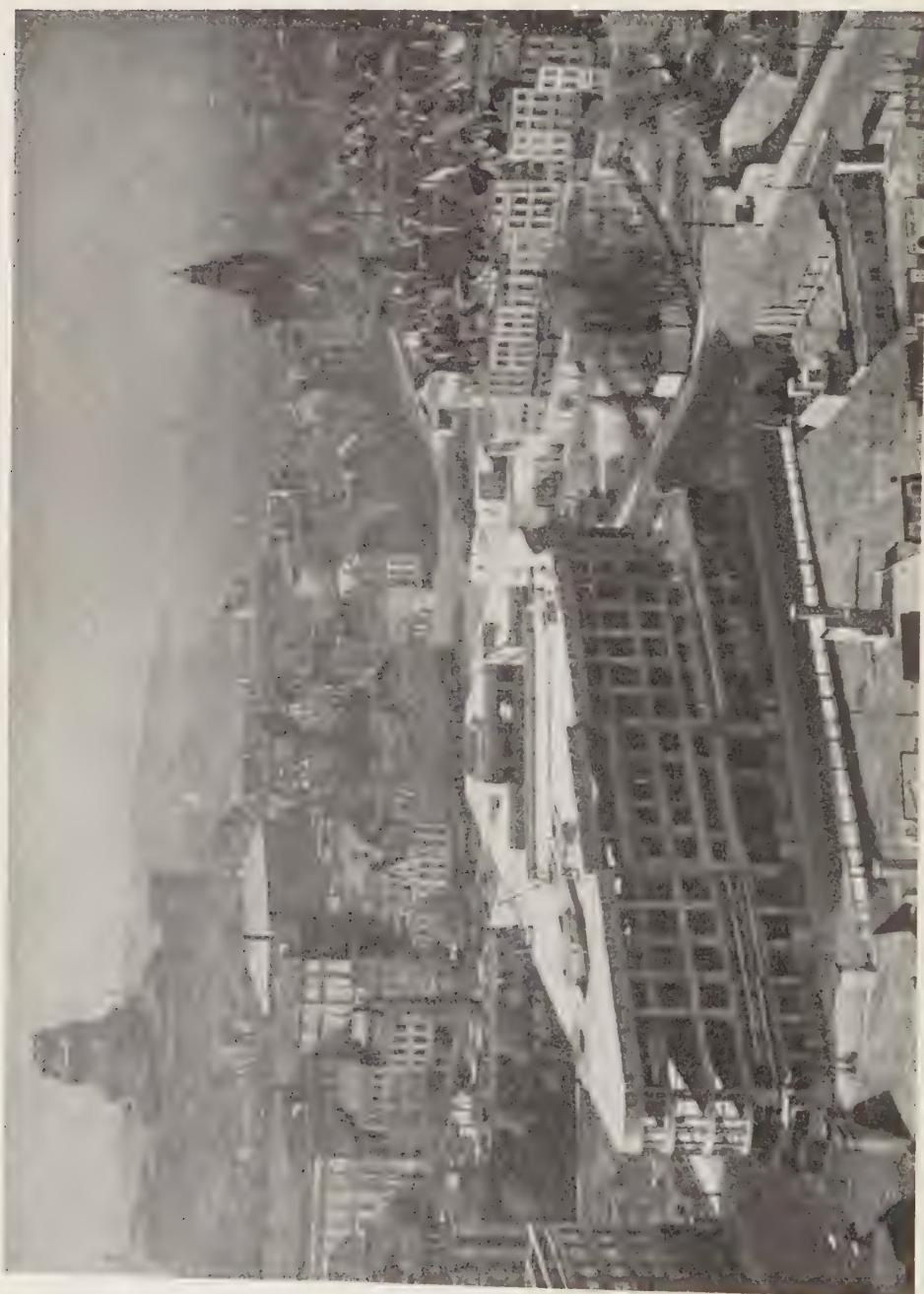


Fig. 39.— Panoramic view of the building at the Central Halt.

(Photo Van Haute)

### V.—Central Halt.

The design of the Central Halt came up against numerous difficulties on account of the limitations imposed by having to build a triangular building (due to the layout of adjoining streets) above an underground station lying on a curve.

and the other at the lower level, that of the crossroad (level 34) (fig. 42).

The different stories will be allotted to the administrative or commercial departments.

The underground station consists of a lower entresol (level 30) formed by the extrados of the tunnel, and at level 25.50



(Photo Van Haute.)

Fig. 40.—Central Halt.—View of the north-eastern corner. The main entrance is in the lower corner on the right.

The problem was further complicated by the different levels involved, one street being at a higher level and the other two sloping down towards a cross road.

The general plan is a four story building (figs. 39 and 40) with two ground floors, one at the higher level (level 38) (fig. 41),

the three platforms serving the six through lines (figs. 43 and 44).

The platforms are curved with a radius of 420 and 545 m. (459 and 595 yards) and are about 300 m. (328 yards) long with a maximum width of 8 m. (8.74 yards).



Fig. 41. — Central Halt.  
Plan of the upper entresol (level 38).



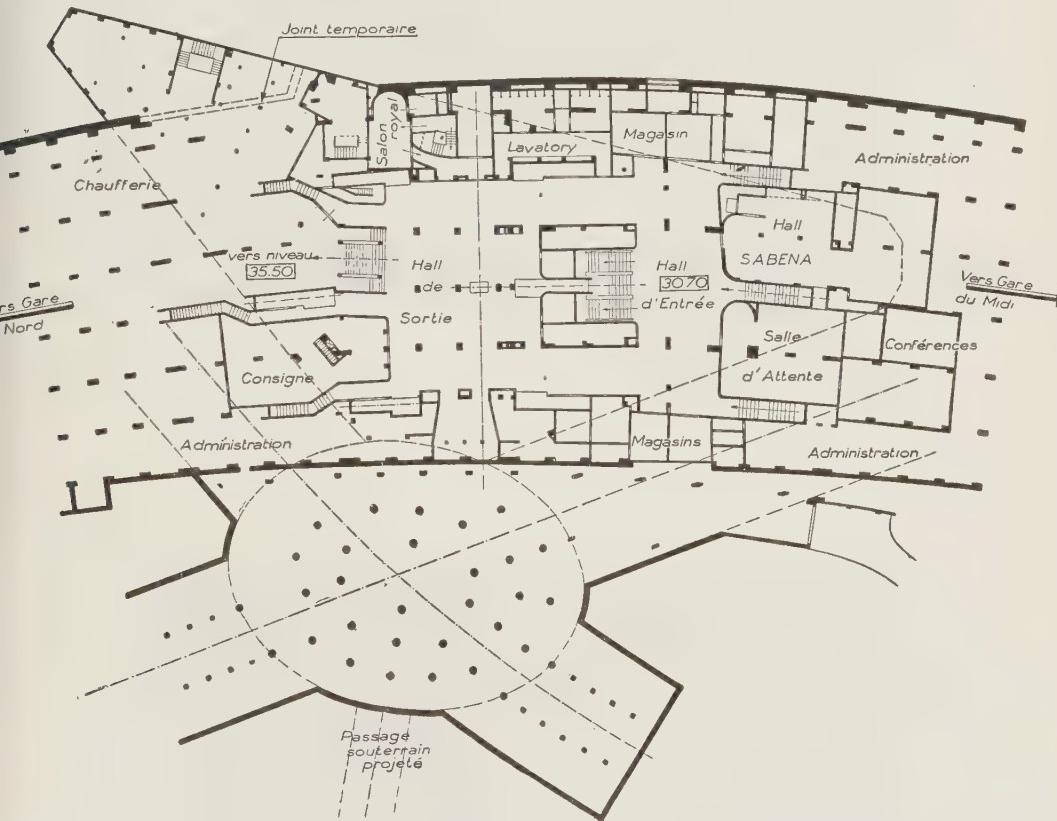
Fig. 42. — Central Halt.  
Plan of the booking hall (level 39).

### 1. Constructional features.

The underground station has been formed by enlarging the normal section of the tunnel from 35 m. (38.27 yards) to 60 m. (65.61 yards).

One outer corner of the triangular building lies outside the tunnel and rests on piles.

Up to the second story the columns and partitions consist of beams encased in



(Cliché Technique des Travaux.)

Fig. 43.—Central Halt.—Plan of the lower entresol (extrados of the tunnel, level 30).

In order to reduce the span of the tunnels, an additional line of columns has been erected in the centre of the platforms (figs. 44 and 45).

The part of the building over the tunnel is supported by the walls and pillars of the tunnel as well by the floor of encased girders of the lower ground story (level 34).

concrete. The top stories on the other hand are made of reinforced concrete.

There are no doors on the outside, these being replaced by air screens. Grills enable them to be closed at night.

It may be recalled that the ventilation of the outlets of the tunnels takes place transversally at the Central Halt, the

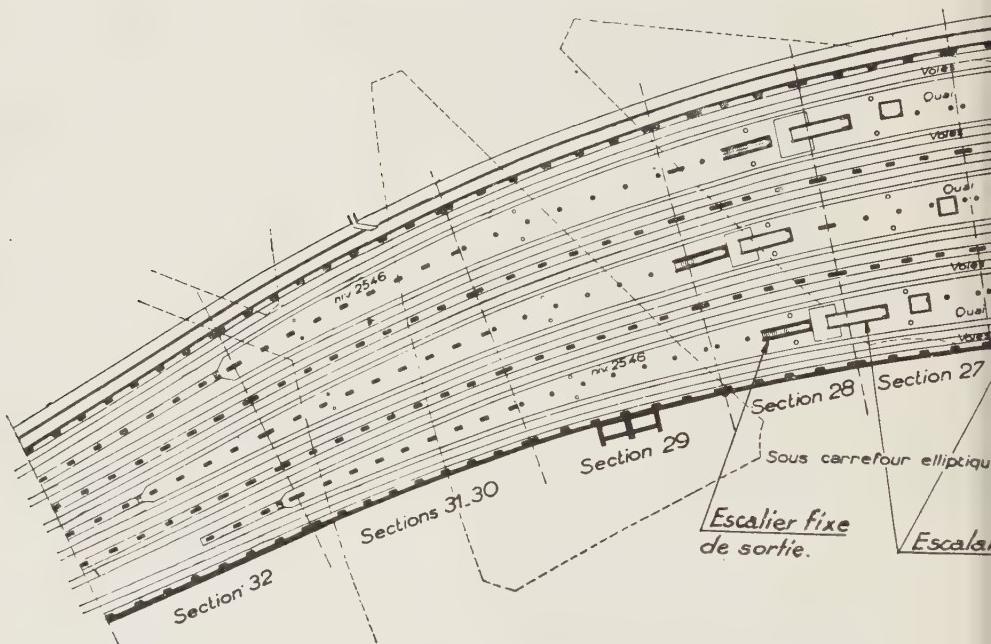
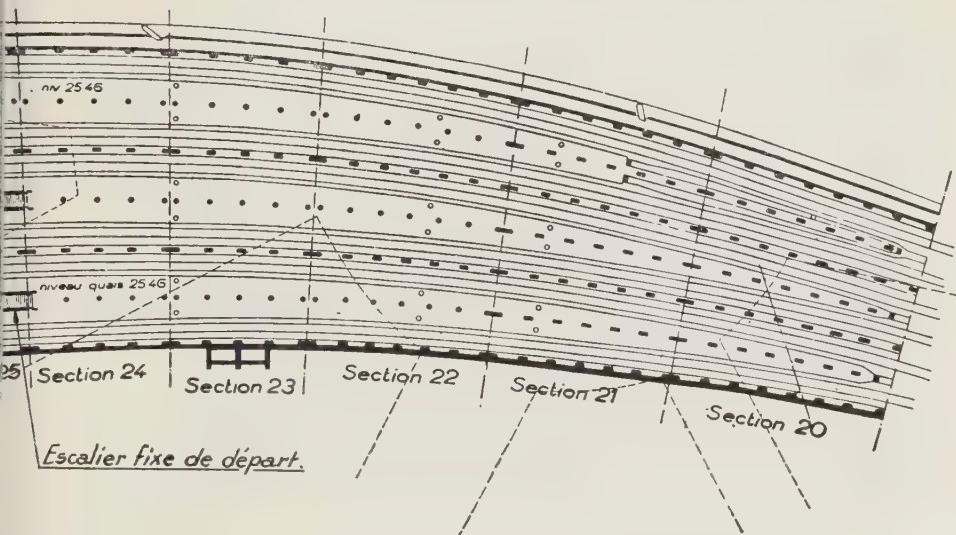


Fig. 44. — Ce

Fig. 45. — Central Halt. — View of the platforms (main work).  
(Photo S. N. C. F. B.)



the platforms.

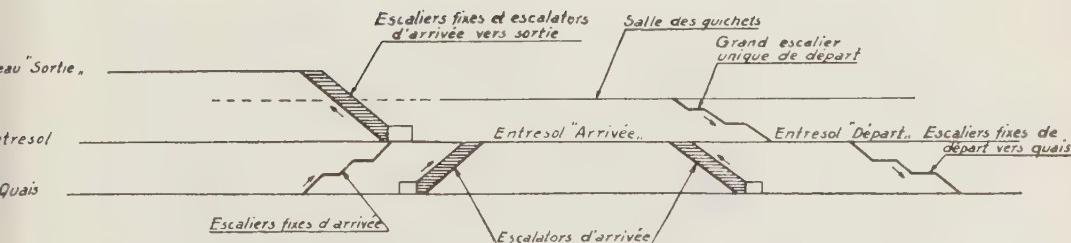


Fig. 46. — Central Halt. — Diagrammatic section showing the way the departure and arrival traffic is kept separate.

*Explanation of French terms.*

Niveau « Sortie » = Level « Exit ». — Escaliers fixes et escalators d'arrivée vers sortie = Stairways and escalators. - Arrival to exist. — Salle des guichets = Booking hall. — Grand escalier unique de départ = Only staircase — departure. — Entresol « Arrivée » = Entresol « Arrival ». — Entresol « Départ » = Entresol « Departure ». — Escaliers fixes de départ vers quais = Stairways to the platforms. — Quais = Platforms. — Escaliers fixes d'arrivée = Stairways. - Arrival. — Escalators d'arrivée = Escalators. - Arrival.

fresh air being drawn in below the edges of the platform and the used air being drawn out through openings in the ceiling.

#### 2. Operating features.

The Central Halt, designed to deal

with suburban passenger traffic, has no registered luggage department.

There is merely a cloakroom where luggage can be left, which can be reached both from the lower entresol and the ground floor.

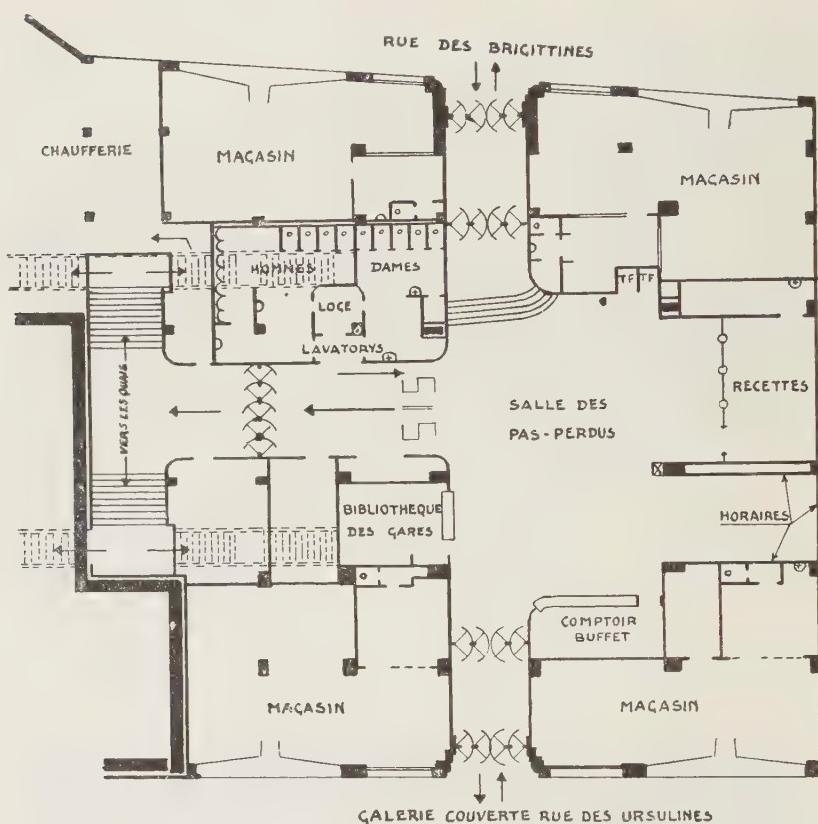


Fig. 47. — La Chapelle stopping point : arrangement of the offices under the track.

One essential feature is the complete separation of the stream of passengers arriving at the station and that of passengers joining trains there, as shown diagrammatically in fig. 46.

In view of the great differences in level between the platform and exit hall, which is about 12 m. (13 yards), mechanical equipment was necessary to clear passengers arriving at the station.

Two escalators link up each platform with the lower entresol (fig. 46), and two others lead from this entresol to the exit hall.

In addition there are stairways between the platform and exit which passengers can use.

As for passengers joining trains at the station, they have to use a huge stairway leading from the bookinghall to the entresol from where there is a stairway (2.50 m. [2.72 yards] wide) leading to each platform.

There are lifts between the booking office and the platforms which can be used by passengers who do not feel equal to using the stairs.

It may be mentioned that it is proposed



Fig. 48. — Brussels Nord. — View of the north end of the tunnel.

The building over the tunnel will be used as a section post; it is intended ultimately to incorporate it in a much larger building of better appearance. The overhead line posts to right and left are permanent structures, whereas the brackets are only temporarily installed for the two existing shunting lines. It will be noted that the tunnel is divided into two outlets, which later on split up into three.



Fig. 49. — View of the south end of the tunnel.

The three outlets can be seen, two of which have been temporarily walled in.

to make an additional exit from the lower entresol by means of a covered subway leading down into the town.

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The platforms at these stopping points are only 200 to 225 m. (245 yards) long.

There are three booking offices at each of them.

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(Photo S. N. C. F. B.)

Fig. 50. — Brussels Midi. — View of the main entrances to the under-track building. (January 1949).

## VI. — Stopping points.

The stops known as « La Chapelle » and « Congrès » are merely halts at which trains can be left or joined with two platforms.

At « Congrès » there are two platforms in the tunnel with a building above the tunnel.

At « La Chapelle » on the contrary which lies on viaduct part of the junction the two platforms are in the open and the building under the track (fig. 47).

## CHAPTER IV.

### STATE OF THE WORK AT THE END OF 1948 AND LIKELIHOOD OF THE JUNCTION BEING COMPLETED AND PUT INTO SERVICE.

#### I. — State of the work at the end of 1948.

##### 1. Junction.

The main tunnel will be completed during 1949. The tunnel has already been made over the whole 1 900 m. of length (figs. 48 and 49).

The Central Halt is practically completed.

In the case of the Congress stopping point, only the part in the tunnel has been completed.

The viaduct connecting the Nord Station to the Junction has been completed. The viaduct on the south side however is not

The Junction will then have to be equipped with its railway lines, overhead lines, signalling, ventilation, etc.

## 2. Stations.

*Midi* : The Midi Station is at present divided into an upper station with 12 platforms (9 of which will ultimately have an



Fig. 51. — Brussels Nord. — View of the left wing of the building. In the foreground the esplanade can be seen under construction. (February 1949.)

yet complete, though quite a large section of this was nearly completed as far back as 1914. The part built at that time will have to be considerably modified. The work is in hand but will not be completed before 1950.

outlet towards the Junction), and a lower station with 5 lines (used for the Charleroi traffic) (fig. 22).

The buildings corresponding to this phase of the work (the 3rd), and in particular the new booking hall, are part-

ially, completed, and have been put into service on the 1st April of this year (fig. 50).

*Nord* : Three lines of the new station with sidings towards the Junction are used for the services on the electrified Brussels-Antwerp line. The lower station consists of an old part with 6 lines and a

piles for the rest of the building and esplanade are now in hand.

## II. — Likelihood of the Junction being completed.

The completion of the Junction depends primarily upon the progress made with



Fig. 52. — Brussels Midi. — View of the work on the town side. (February 1949.)

*In the foreground*, the west part of the bus square.

Then the small quadrangle. Next the metal bridge over the Midi Boulevard, and beyond that the viaduct.

On the right, the remains of the old main building with the two arcades carrying the roof over the track (removed in 1947).

To the left, the contractors yard, surrounded by remains of the old station.

temporary station at the side with 6 more lines.

About one third of the building (fig. 51) has been completed since 1940. The esplanade is now being constructed in front of the completed wing of the building. The building of the foundation

the work at the Nord Station, and on the quadrilateral containing the ladder track towards the Junction in the south.

In the case of the *Nord* : we have already shown the difficulties in the way of carrying out the work of raising the level at the Nord Station.



(Photo S. N. C. F. B.)

Fig. 53.—Brussels Midi.—Foundations of the catenary pillars for the south ladder track. These foundations will finally be incorporated in the future embankment.

To raise the level of the 9 platform lines, two phases have still to be completed (the 5th and 6th), in five stages.

This work, according to the theoretical planning based on the time taken for the work already done, should be completed by the 1st September 1953.

When these two phases are completed, a 7th phase will have to be undertaken, in order to put the main lines on the north side into position and make the final ladder track.

In the case of the *Midi* : 10 lines have still to be raised, which work can be done

in two phases covering 4 and 6 lines respectively without any secondary stages, and it is expected to complete it by the end of 1950. The building under the tracks, under the ladder track towards the Junction has not been able to keep pace with the general work as it is sited on the old receipts building which has just been given up now the new under-track installations have been put into service.

The completion of the quadrilateral formed by the lines on the Junction side is expected in 1952 (fig. 52).

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According to the general planning, the Junction and stations will only be completed as a whole in 1954. However the progress of the work which came up against many difficulties due to shortages of materials after the war, has now come up against financial difficulties. It all depends therefore to a large extent on the attitude of the Public Authorities towards subsidising the work.

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### III. — Likelihood of the Junction being put into service.

It must be pointed out that the work of raising the level of the platform lines is taking place from east to west at the Nord Station and from west to east at the Midi Station. This involves raising the level of half of the two stations before traffic can run from one end of the Junction to the other. It is premature to speculate at the present time when the Junction will be completely open to traffic.

However the first two stages can already be foreseen.

#### 1. Partially putting into service of the Central Halt.

The Belgian National Railways, in collaboration with the Junction Office, are doing their best to extend the electric trains from Brussels to Antwerp as far as the Central Halt.

This partial use of the Junction entails completing and equipping the Eastern outlet as well as the partial completion of the Central Halt.

It is likely to take place towards the beginning of 1951.

#### 2. Transit through the Junction.

As soon as the completion of the central line from Brussels Nord makes it possible to transfer the Liege traffic to the raised up lines and as soon as the quadrilateral from Brussels Midi and the viaducts are completed to allow them to run, it will be possible to extend certain trains from Liege through the Junction and on to Ostende.

This partial opening of the Junction is likely to take place during 1951.

### CONCLUSIONS

The Nord-Midi Junction now being completed in Brussels represents a very considerable undertaking. It has come up against all sorts of difficulties : two world wars, an interruption of 17 years after the 1914-1918 war, etc.

It is to be hoped that it will now be completed without any further delays.

Brussels will then have an up-to-date railway centre, which from many points of view will have no counterpart anywhere else in the world.

# Deformation of the permanent way by heat,<sup>(1)</sup>

by R. LÉVI,

Directeur,

Chef du Service Technique des Installations Fixes de la Société Nationale des Chemins de fer français.  
(*Revue Générale des Chemins de Fer*, May 1948.)

## General.

Deformation of the permanent way due to variations of temperature has already formed the subject of much research, usually of an experimental character. The tiresome nature of the calculations which have to be dealt with for the theoretical research explains why it was preferred as a general rule to leave them aside. But then one is apt to be influenced by all the secondary effects which affect the stability of the track, so that it is no longer possible to deduce a general law.

However, the field is quite open to reasoned argument and the calculations that have to be made do not themselves present any difficulty. In this respect the article by M. Martinet in the *Revue Générale* of 1936 (2) may be consulted. In an article published in the *Génie Civil* of 1932 (3), we have already shown that the calculation leads to the conclusion that deformation by heat is not possible, provided the track is packed in the normal way and has a straight lengthwise profile, but that it will become so deformed if, starting with this state of affairs, one supplies an addi-

tional amount of energy to the track; the amount required to bring about this deformation will depend on the equipment of the track. To this we added : « It is necessary to consider the effects of the passage of trains — and particularly — a fact usually omitted in studies of stability of the permanent way — the rising of the rail, due to its continuity at both ends of the train ».

The paper by M. Martinet, who uses the same equations, concentrates on the case where the track is lifted by the action of a man and where the track is entirely freed from ballast. Even under these hypothetical conditions, the earlier conclusions are not invalidated, except in the case of sharply curved tracks.

We propose here to set out a summary of the research begun in the above-quoted article from the *Génie civil*, which we wrote and which has recently found an application in the field of bursting of jointless tracks brought about by the heat. In the meantime, the technique of jointless steel tracks (these can be considered as continuous bars of over 1 km. in length) has been generalized, especially on the network of the « Delaware & Hudson », without any incident occurring which might disclose any risk of deformation due to the heat. This confirmation invalidates those over-simple ideas which were formerly current in this respect; it shows that a rail track can very well resist longitudinal stresses, of the order of about 100 tons, when expansion by heat is made impossible, without its stability being imperilled.

Actually, now we are forced to complain

(1) The author has discussed the same problem, but in a slightly different form, at the « Centre d'Etudes Supérieures de l'Institut Technique du Bâtiment et des Travaux Publics »; his paper was reproduced in a circular of this Institute, on 25-9-47, entitled « The dangers of upheaval of the track and permanent way. »

(2) *Revue Générale des Chemins de fer*, Oct. 1936, « Buckling of the tracks without joints on ballast and rails of great length » by A. Martinet.

(3) *Le Génie Civil* — Vol. 11, No. 8, 20-8-1932. « Longitudinal displacements of rails and buckling of the track » by Robert LÉVI.

of deformations of the track due to the heat and these incidents most often affect old tracks, where the gaps in the joints are precisely calculated with a view to authorizing all thermal expansions that theoretically correspond to the temperature variations.

How does this contradiction arise, that the only cases where the heat effect is noticeable are those where precautions had been taken to prevent them? It is a matter of interest to the theorist to find the explanation.

Undoubtedly, the classic arrangement, which consists in providing expansion joints fully satisfies the spirit of the instruction. But it is essential that the gaps *as designed* should be maintained. Now, though this is generally true in the case of bridges or buildings, in the case of the permanent way, it may be said that only in exceptional circumstances, the centre lines of the rails keep their position and that the joints are not partly or completely choked by the burrs due to the hammering of the rails ends.

Thus the gaps left at the joints when the track is being laid do not protect it absolutely from the bad effects of thermal expansion. These gaps are diminished by attacking the creepage, which tends to displace the centres of the rails and by suppressing the burrs. But there remains a risk which should be understood and appreciated.

To this, one is tempted to object, that partial freedom at the joints, even if it is only accidental, when the rails are relatively short, is preferable to total lack of freedom in a long length of track, hence it is argued that it would be better to stick to the old practice, which allows the thermal expansion to show itself in normal conditions, than to stop it entirely, thus locking up considerable stresses in the rail.

This argument lacks force.

It can always happen on a jointed track, that on account of exceptional circumstances

— sudden application of the brakes, creepage not adequately counteracted, entry into the joint of a foreign body — a whole series of joints may be blocked at a moderate temperature. An ultimate increase of the latter will have the same effect in the middle of the blocked length as if the whole length had been laid without any intermediate joints. One cannot therefore be sure of avoiding the thermal stresses, unless accidental blocking of the joints were made strictly impossible.

If this is not done, then in the alternative one must look out for two harmful effects from these joints :

1. The fishplates, no matter how carefully they are fitted, will not provide perfect rigidity. These then are weak spots in the track especially in the vertical sense, where the tendency to deformation may easily take effect.

2. The blocking of the joints may have a certain eccentricity, which increases the bending moments due to compression of the rails, whence arises an increased tendency to deformation.

Do these two adverse factors do more or less than counterbalance the benefit generally imputed to the open joints? That is the important question which we shall try to solve.

#### Hypotheses on which the calculations are based.

We shall assume that in the case of a track where the ballast has *not* been removed, the sleepers are too well anchored in the ballast for a transverse rail deformation to take place without the track first being upheaved.

Hence, the problem is to assess the likelihood of the track, subjected to longitudinal compression, lifting under such stress. The track, once it is lifted, will no longer be able to resist horizontal deformation.

The following symbols will be used :

$S$  = the combined section of the two rails;

$\rho$  = radius of gyration of each rail in the vertical plane;

$E$  = the modulus of elasticity;

$P$  =  $ESu^2$  total compression stress in the two rails;

$\delta$  = imaginary density of a bar of section  $S$ , which would have the same average weight as the track;

$\alpha$  = coefficient of thermal expansion of the rails;

$\theta$  = increase of temperature above the normal state.

In the case of the Standard track supplied with 46 kg. (102 lbs.) rails, we get the following values :

$$\rho = 5.18 \text{ cm.}$$

$$\frac{P\delta}{E} = 45.10^{-9},$$

This quantity is non-dimensional, the same applies to the relation :

$$u^2 = \frac{P}{ES}$$

which is none other than the relative shortening attributable to the compression. This relative shrinkage for a bar strictly incapable of expansion under the influence of temperature, amounts to  $10.5 \cdot 10^{-6}$  per degree of increase above the neutral condition.

If now we seek a condition of equilibrium very near to the point of rest, we see at once that there is no solution to this problem, no matter what might be the value of the compression, provided the track does not include any singularity.

Hence, we shall start with the assumption of a singularity and will suppose, for this purpose, that the longitudinal section is fractured and that the two sloping parts are rectilinear. Further we will imagine that there may be a joint at the apex and that at

this point the fished joint has its centre of gravity displaced as regards its height in relation to the centre of gravity of the rail section.

Let us take the origin for the abscissae, as the point where the curve of pressures is horizontal :

Let :

$x$  be the abscissa at one point of the track;

$y$  the elongation at this point, of the lifting;  $i$  the slope, in both senses, of the two sides of the longitudinal section before lifting takes place;

$\phi$  a variable auxiliary;

$\varepsilon$  deviation of the resisting sections at the joint;

$K$  the coefficient of rigidity of the fished joint defined in following way.

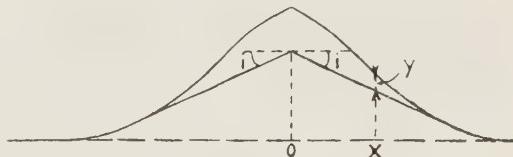


Fig. 1

We admit that there is proportionality between the moment in the fished joint and the sum of the angular deviations in the neutral axes on one side or the other.

For reasons of symmetry, we must assume that the curve of the lifting effort is symmetrical in relation to the apex. So that we have :

$$M = ES \rho^2 y''(0) - Pe = ES [\rho^2 y''(0) - u^2 \varepsilon]$$

whence :

$$\rho^2 y''(0) - u^2 \varepsilon = 2K \rho y'(0) \dots (1)$$

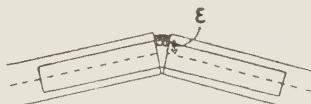


Fig. 2

$\frac{1}{K}$  represents the length of rails as related to the radius of gyration, in which a moment  $M$  produces the same angular deviation as it would applied to a single plate fish joint.

**Equilibrium of the lifting effort.**—This being any position of equilibrium satisfied by the  $x$  positive values in the differential equation :

$$ES \rho^2 y'' + ES u^2 (y - ix) + \frac{S \delta}{2} x^2 = C^{te} \quad (2)$$

which is solved by the equation

$$\begin{aligned} y &= -C \cos \frac{ux}{\rho} - D \sin \frac{ux}{\rho} \\ &\quad - \frac{\delta}{2 E u^2} x^2 + ix + C^{te} \end{aligned} \quad (3)$$

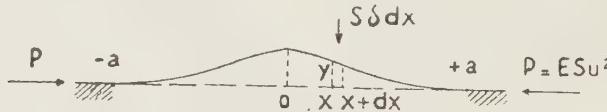


Fig. 3

In the limit these conditions define the final constant such as  $C$  and  $D$  and provide a relationship between  $u$  and the other parameters.

These conditions express, in the first instance, that at each drop of the abscissa :

$$\pm a = \pm \frac{\varphi \rho}{u} \quad (4)$$

the elongation  $y$ , its first and second differential coefficients are = zero. This latter condition is due to the fact that at these points the rails cannot receive any support by housing. Thus we have :

$$\left. \begin{aligned} y' \left( \frac{\varphi \rho}{u} \right) &= C \frac{u}{\rho} \sin \varphi - D \frac{u}{\rho} \cos \varphi - \frac{\delta \varphi \rho}{E u^3} + i = 0 \\ y'' \left( \frac{\varphi \rho}{u} \right) &= C \frac{u^2}{\rho^2} \cos \varphi + D \frac{u^2}{\rho^2} \sin \varphi - \frac{\delta}{E u^2} = 0 \end{aligned} \right\} \quad (5)$$

whence :

$$\left. \begin{aligned} C &= \frac{\rho^2}{E u^4} (\cos \varphi + \varphi \sin \varphi) - \frac{i \rho}{u} \sin \varphi \\ D &= \frac{\rho^2}{E u^4} (\sin \varphi - \varphi \cos \varphi) + \frac{i \rho}{u} \cos \varphi \end{aligned} \right\} \quad (6)$$

The equation (1) may now be written :

$$\begin{aligned} \frac{\rho \delta}{E} &\left[ u(\cos \varphi - 1 + \varphi \sin \varphi) + 2K(\sin \varphi - \varphi \cos \varphi) \right] \\ &- iu^3 \left[ u \sin \varphi + 2K(1 - \cos \varphi) \right] - \frac{u^5 \varepsilon}{\rho} = 0 \end{aligned} \quad (7)$$

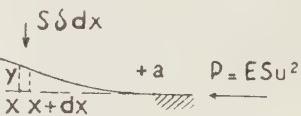
#### Discussion of the outcome of this calculation.

One sees that within certain limits of validity, the variable auxiliary  $\varphi$  defines, by (7),

the variable  $u$  which typifies the compression, by (4) the length of the lift and its height by (6).

At least in the interval between 0 and  $\pi$ , the auxiliary variable  $\varphi$  provides a real sense to these solutions.

When  $\varphi$  is small, all the characteristics of the lift will be small. Consequently, if compression increases above zero in a bar of which



the longitudinal section is interrupted near the bottom, a lift is theoretically indicated towards the apex and then increases at the same time as the compression. However we must hasten to point out that the theoretical height of this lift, is of an infinitesimal order, which allows us to neglect it when  $\varphi$  is not at least equal to  $\frac{\pi}{2}$ ; in fact it increases as the 4th. power of the compression.

If  $\varphi$  increases still further, it will be realized that  $u$  reaches a maximum. That is, for a still greater value of  $u$ , equilibrium is no longer possible. Its weight is no longer sufficient to counteract the compression.

In actual fact, the deformation of the track due to the heat does not exactly follow this process. Just as it is pointed out in the above-quoted article of the *Génie Civil*, the lifting of the track is accompanied by an expansion (détente) of the rails in the adjacent parts, so that if  $P_0$  is the general compression before lifting takes place, the value of  $P$ , the pressure of the lifting wave, falls in proportion as the value of  $P_0$  rises.

It is none the less true that the effective pressure cannot reach a certain critical value without the lifting action acquiring an explosive character and that this value is a value

more or less approached by a lack in the critical value of  $P_0$ .

Hence it is important to evaluate it.

To do this we select the first member of equation (7) namely,  $\frac{\delta \xi}{\delta u} du$  and from this we derive the equation :

$$\frac{\delta \xi}{\delta u} du + \frac{\delta \xi}{\delta \varphi} d \varphi = 0$$

The critical value of  $u$  is given by :

$$\frac{d u}{d \varphi} = 0$$

whence :

$$0 = \frac{\delta \xi}{\delta \varphi} = \frac{\rho}{E} \left( u \varphi \cos \varphi + 2 K \varphi \sin \varphi \right) - i u^3 \left( u \cos \varphi + 2 K \sin \varphi \right)$$

or

$$\left( \frac{\rho \varphi \delta}{E} - i u^3 \right) \left( u \cos \varphi + 2 K \sin \varphi \right) = 0 \quad (8)$$

Consideration of this equation shows that practically only the second factor of the first member can be annulled. Whence by calling  $U$  the critical value for  $u$ ,

$$U = - 2 K \operatorname{tg} \varphi \quad (9)$$

This equation must be associated with (7). Here we introduce a new value, to be called  $h$ , which stands for the vertical bend before deformation of the track measured lengthwise where the lifting takes place, i. e. :

$$h = \frac{i \varphi \rho}{U} \quad (10)$$

By combining (7), (9) and (10), we get :

$$\frac{h}{L} + \frac{\varepsilon}{N} = \frac{\rho^2 \delta}{E U^4} \quad (11)$$

with

$$L = \frac{\rho^2 - \varphi \sin \varphi}{1 - \cos \varphi} \quad (12)$$

$$N = \frac{\varphi - \sin \varphi}{\sin \varphi}$$

Note that  $\operatorname{tg} \varphi$  and  $\cos \varphi$  are negative in accordance with (9),  $\varphi$  then having a value between

$\frac{\pi}{2}$  and  $\pi$ .

### Critical values of the compression.

The equations (9), (11) and (12), we add the relationship between  $0$  and  $U$ , i. e. :

$$U^2 = \alpha \theta \quad (13)$$

In this system, the variables which concern us as definite values are  $K$ ,  $h$ ,  $\varepsilon$  and  $\theta$ .

The various possibilities should then be shown by diagrams indicating the values of  $\theta$  as a function of  $K$ ,  $h$  and  $\varepsilon$ . The analytic character of the above equations as well as the number of variables being given, these diagrams would be difficult to verify and to read.

But one can obtain an imaginary presentation of these possibilities by means of a monogram with the points aligned.

Set off on two parallel, semi-straight lines (demi-droites parallèles), segments of lengths proportional to  $h$  and to  $\varepsilon$ . In a system of values of  $U$  and of  $\varphi$ , the straight lines joining the extremities of these segments pass through a fixed point, in accordance with (11). By joining up the points of convergence where  $U$  and hence also  $\theta$  are of equal value, and by proceeding in the same way for the points, where according to (9),  $K$  has the same value, we get a field graduated according to  $\theta$  and to  $K$ .

In constructing this diagram, we have restricted ourselves to curves  $\theta = 20^\circ$  and  $\theta = 40^\circ$ . The last of these values corresponds to the case where, the rail being in the neutral state at a temperature of  $20^\circ$ , its temperature had risen to  $60^\circ$  without any expansion in length; such is the case which one may look for in rails of very great length. The first of these values, corresponds to a partial liberty of movement, which for the same temperature variation, manifests itself in the closing up of the joints by an amount equal to 50% of the thermal expansion, the other half being stored in the rails as a compression stress; this is a case which is undoubtedly met with in practice.

It will at once be observed that the track is not susceptible to « buckling », to use the

time-honoured expression, for  $\theta = 40^\circ$  unless there was an initial sag of more than 6 cm. ( $2\frac{3}{8}''$ ) [on a length of some 15 metres ( $49' 2\frac{1}{2}''$ )].

if at the peak of the variation of level, there is a blocked (closed) joint having an eccentricity of 5 cm. ( $2''$ ) and if  $K = 0.75$ .

If now we imagine a blocked joint having

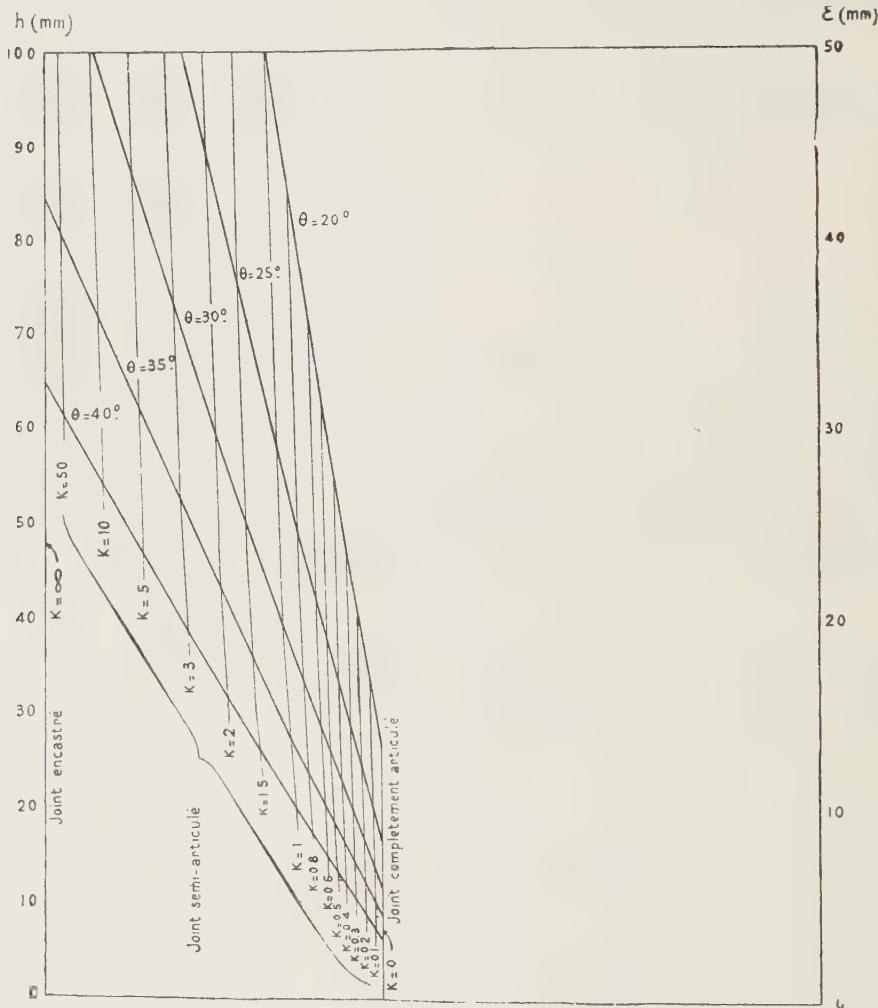


Fig. 4

This would appear to be a state of affairs which should not be permitted on a main line properly maintained and inspected. But for the same bend, there is a drop to  $\theta = 20^\circ$

this eccentricity without any initial sag, we observe that the deflection can take place for  $\theta = 20^\circ$  and  $K = 0.2$ . Is it permissible to exclude such an hypothesis? We think not.

It should in fact be pointed out that the blocking of the gap at the joint can be perfectly well effected at the upper part of the head of the rail, that the 50% allowed for the thermal expansion is perfectly reasonable, especially in the case of lines for goods traffic, where inspection is less strict than for main lines and that the fish bolts are subject to great variation of their tightness which has a notable effect on the rigidity of the joints.

As regards the effective values of the coefficient of rigidity, we think that this may fall to 0.05. In the comparative bending tests on standard rails of 46 kg., in one case for continuous rails and the others made up with fish plate joints, we have observed double the flexure in the second case, this flexure being noted on a chord of 2 m. (6' 6 3/4"). The pivoting of the rail in each joint is therefore equivalent to the angle of contact (spring of curve) in a length of 0.5 m. (1' 7 11/16") or say 10 times the radius of gyration. For K this corresponds to 0.1.

It is undeniable that the results of calculations similar to those here described, even

when a large number of factors are introduced, must be treated with caution. The results can only be looked upon as indicators.

Among the factors, which have been deliberately neglected, we recall the elastic lifting of the rails due to its continuity.

Nevertheless, this discussion leads to certain definite conclusions : It is not enough to provide joints for expansion, if one is not satisfied that the freedom of movement in these joints will never meet any obstruction.

On the contrary the existence of joints is favorable to the lifting, when they are found likely to be blocked and this being due to their lack of rigidity.

The blocking of the joints (gaps) is particularly dangerous when it occurs with a marked eccentricity.

The stability of the permanent way should be enhanced by rail joints (which can be very far apart) which would be :

- a) rigid in respect to the vertical plane;
- b) designed so as to render impossible the introduction of bodies which restrict (longitudinal) expansion of the rails.

## Double-deck railway carriages.

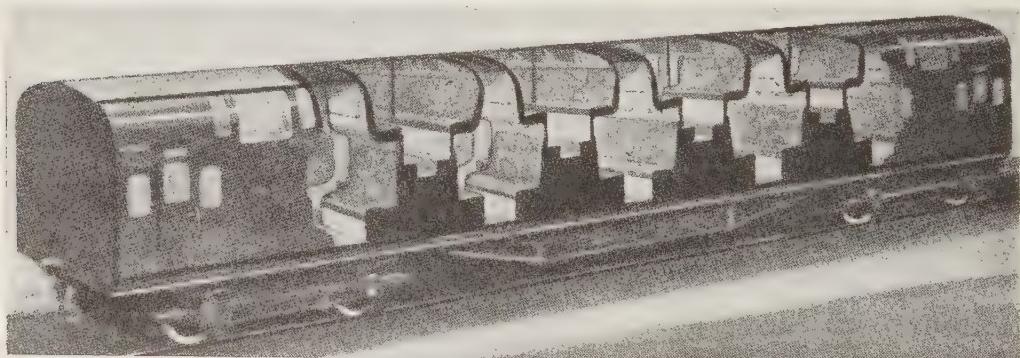
Mock-up for Southern Region displayed,

EXPERIMENT FOR SUBURBAN TRAFFIC.

(*Modern Transport, March 5, 1949.*)

Dense suburban traffic has long been a problem of great difficulty to railway managements, and British Railways is to build an experimental double-deck train to ascertain its possibilities as a solution. Peaks have hitherto been met by providing greater acceleration (usually by electric traction), closer headways as a result of resignalling, and the maximum capacity in

Some alleviation has been obtained by providing extra trains via Lewisham and Nunhead to Blackfriars, but these are not very popular. In a typical peak hour (between 5 and 6 p.m., Monday to Friday), 38 electric and eight steam trains are handled in the down direction at Borough Market Junction where the Cannon Street and Charing Cross routes converge just



An artist's sketch showing the Southern Region double-deck carriage partially sectioned.

the coaches. On the Southern Region of British Railways the suburban services from Charing Cross and Cannon Street have been particularly affected by housing developments and by the shortening and intensification of the peak periods through changed social conditions. This applies with special force to the four routes to Dartford, whether via Lewisham and Woolwich (the original North Kent Line), Greenwich, Bexleyheath or the Dartford Loop via Sidcup.

outside London Bridge; this, representing a total of 92 trains in both directions over a flat junction, must be looked upon as practically the maximum possible figure, only attained by the skill of timetable compilers in arranging the service and the signalmen in working it. The enlargement of the capacity of each train was therefore next examined; mere reduction of seating to provide greater standing capacity was not entertained in view of the considerable length of many suburban journeys. It is

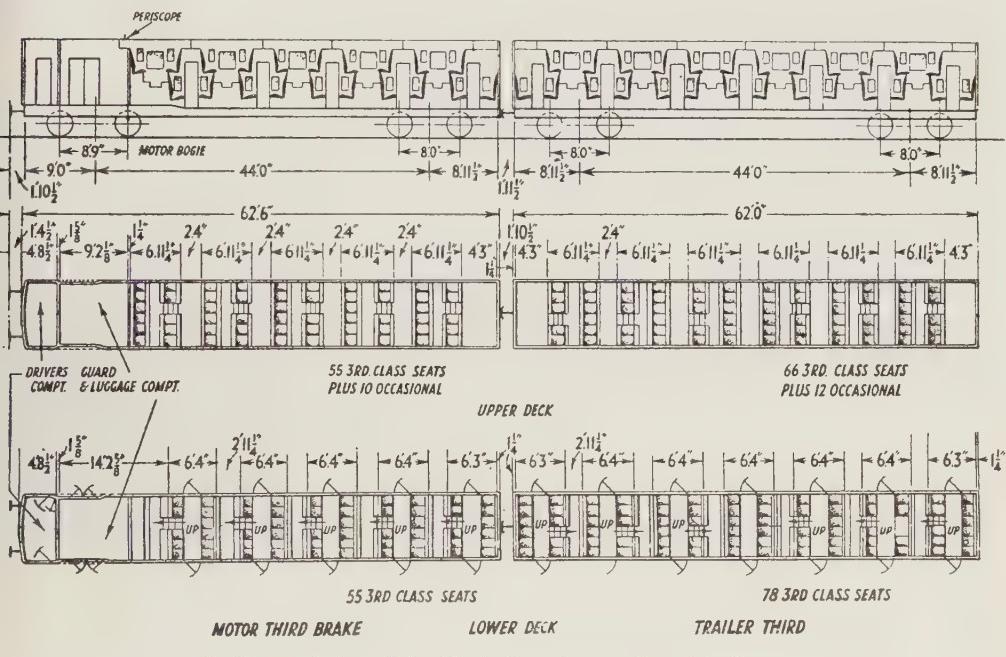
not unusual to find trains filled to capacity on a journey of over 30 min. from the city terminus.

### **Train capacity changes.**

The standard formations of Southern suburban trains, with two sets of three cars marshalled either side of two trailers, and later of two four-car sets, were arranged

in each coach, with three seats one side and two the other of the gangway. This arrangement reduced the number of seats to 764, but the latest units contain three complete saloons and one compartment coach, with additional compartments, providing 776 seats per eight cars.

From one point of view it would be easy to extend suburban trains to, say, ten cars, adding a two-coach multiple-unit set for



## Section and plan of double-deck motor coach and trailer car

to average about 652 seats. This stock seated five passengers each side of a compartment, and following alterations to the structure gauge completed just before the war, ten new four-car sets, with seats for six-a-side, were introduced. An eight-car formation of this type held 912 passengers. Unfortunately these units leave too little space between seats for comfort and the next batch had wider compartments, reducing the number of seats to 840. A third delivery incorporated a number of saloons

peak-hour strengthening. Unfortunately, however, the estimated cost of consequential station and track alterations is estimated at many millions. Cannon Street and Charing Cross both provide room for just eight coaches on the platforms; extension of platforms on to the respective river bridges would be extremely costly, while extension of the tracks through the present circulating areas, with new concourses reached by stairs from street and platforms, would be both expensive and inconvenient.

for handling large crowds. Complications would also arise at many suburban stations where existing platforms for eight-coach trains are placed between, say, junction and road bridges, as at Lewisham Junction, between tunnels, or other obstacles.

Investigations were therefore made last year of the possibilities of double-deck rolling stock for suburban purposes. As an article in our April 24, 1948, issue pointed out, double-deck coaches have not

### Double-deck proposals.

Mr. O. V. Bulleid, chief mechanical engineer, Southern Region, has, however, evolved a notable design of double-deck coach which comes inside the British loading-gauge, being only 12 ft. 10 1/2 in. from rail level to top of roof, and which retains one door to 22 seats. In a trailer coach there are seven platform-level compartments; the three at each end have six seats on one side, and on the other

### COMPARISON OF DOUBLE-DECK AND SINGLE-DECK SUBURBAN COACHES

Rolling stock	Seats	Seats per door (one side only)	Capacity with standees	Passengers per door max. (one side only)	Seats per foot of length
<b>DOUBLE-DECK :</b>					
Western of France, four-wheel, 1899 .	76	13	—	—	2.7
Long Island, eight-wheel, 1932. . . .	120	60	—	—	1.6
French State, eight wheel, 1933. . . .	115	58	257	129	1.5
Lubeck—Buchen, articulated, 1935 .	150	75	—	—	2.0
Southern Region, projected, 1949. . .	156	22 (+2)	234	33	2.5
<b>SINGLE-DECK :</b>					
K.N.E.R. (G.E. Section) articulated .	96	12	144	16	2.2
Southern Railway wooden trailer . . .	110	10	176	16	1.8
Southern Railway steel trailer . . . .	120	12	180	18	2.0

proved very successful on railways elsewhere in the world, either failing on passenger amenity or actually carrying fewer seated passengers per foot run of length than a single-deck compartment coach. Except for early French designs they have all been of end-door types which are inherently unsuitable for suburban operation, one having only one door to 75 seats, as compared with a ratio of 1 to 12 on Southern Region single-deck six-a-side stock. As station stops are rated at 1 min. at London Bridge and 20 sec. elsewhere, such stock would never be able to keep time, with consequent sharp reduction of track capacity.

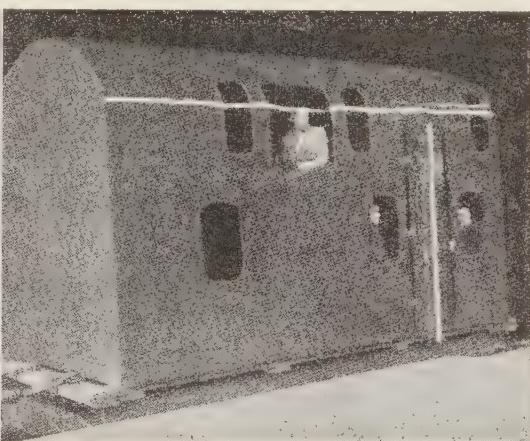
three seats and two, with steps in the gap leading to the upper compartment, which has the same seating. The centre compartment is a 12-seater. Thus virtually there are 13 compartments on a ten-compartment underframe. By courtesy of the Railway Executive we have been able to examine a mock-up of a section of the proposed double-deck coach.

### Mock-up on view.

The compartments are interlaced; i.e. above each lower seat the roof curves outwards to accommodate the seat of the upper compartment. As a result the lug-

gage rack accommodation is limited in lower compartments; in the upper compartments there is, however, considerable space at the backs of the seats for parcels. The headroom on each compartment floor is ample. The capacity of a motor coach with driver's, guard's and luggage compartments and five lower and upper com-

those seated to read without interference from the shadow of passengers standing or moving from one part of the coach to another. Grab handles will be carefully placed to assist movement between the two decks and to assist standing passengers in the lower deck. Owing to the close clearances of bridges and tunnels, the win-



The mock-up of the double-decker, showing a view in the upper compartment, and, right, the specimen compartments standing on a well wagon.

partments on a 62 ft. 6 in. underframe is 55 lower-deck seats and 55 above, plus ten occasional seats under the windows of the upper compartments, a total of 120. The seven lower and six upper compartments of a trailer on a 62-ft. underframe accommodate 144 passengers plus 12 on occasional seats, or a total of 156. The total of seats for a four-car set is thus 552, or 1 104 in an eight-car train, of which 1 016 are comfortable standard seats. Allowing six standing passengers per compartment, the gross peak-hour load should be about 1 656.

Strip-lighting over the seats will help

dows for the upper deck will be fixed. Electric fans will provide constant ventilation in the upper part of the coach, while the doors and windows of the lower deck will be of the normal type. Standard Southern Region electric set underframes, buffering gear and bogies are proposed. It is hoped a test train will be available in the autumn, in order that trials in service and investigations of what longer station time, if any, is required, may be carried out. The cost of a double-deck eight-car set may be as much as £ 70 000, as compared with roundly £ 50 000 for a standard eight-car unit today.

## The « Leader » class locomotives, Southern Region.

(*The Railway Gazette, November 19, 1948.*)

In his address to Section G (Engineering) of the British Association for the Advancement of Science, at the Brighton meeting on Friday, September 10, Mr. O. V. Bulleid, Chief Mechanical Engineer of British Railways, Southern Region, gave some advance information about the new « Leader » class of twelve-wheel tank locomotive, now in an advanced stage of construction at Brighton. A brief mention of this was made in an editorial note in our issue of September 24. The « Leader » design is certainly the most revolutionary to have advanced from the drawing-board stage to actual construction, since the Paget locomotive emerged from Derby over 40 years ago. The first locomotive of the « Leader » class was on view to those taking part in the British Association's meeting, at the Brighton Works, on the afternoon after the delivery of Mr. Bulleid's address. Its chief novelties lie in the elimination of the firebox water-legs; the provision of two three-cylinder sleeve-valve engines of special design (one for each six-wheel bogie); the move towards total enclosure of moving parts and springs and arranging for their continuous lubrication; the substitution of chains for coupling rods; and the adoption of special new devices and measures for prolonging the period of service between boiler wash-outs, to a length of time outside all normal experience in this country.

In his address Mr. Bulleid introduced the « Leader » class with the remark that there is much work for which tender engines are not necessary. To cover such duties and thereby meet practically all requirements, a tank engine is needed, able to work passenger

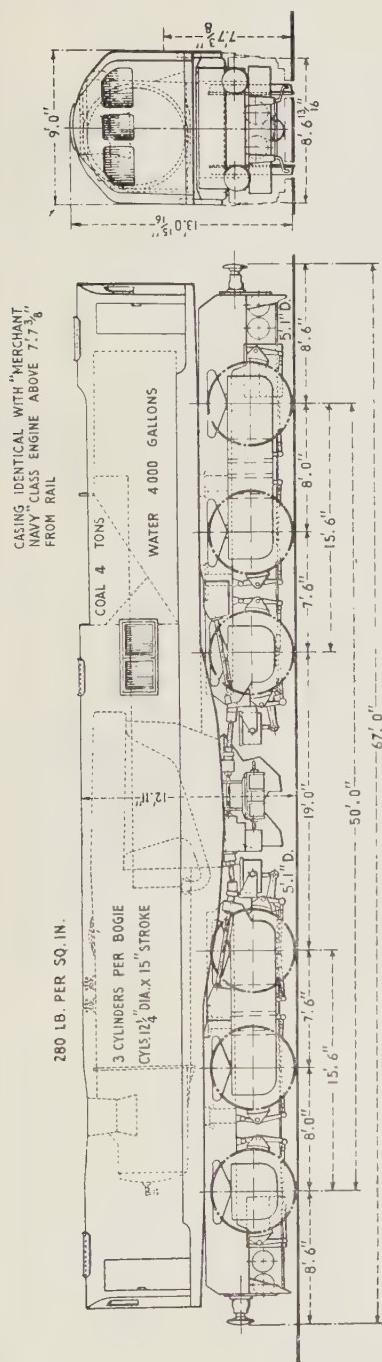
and goods trains over all the Region, with unimportant exceptions.

As the design of the « Leader » class incorporates many new features, five of these engines are being built, so that they can be tried out in all classes of traffic over the whole Region. Two six-wheel bogies carry the engine, and the whole weight is available for adhesion, both for driving and for braking. The engine is designed to run equally well in either direction. A driving cab is provided at each end, so that the driver shall have a full view of his signals and of the track.

The valve motion, connecting rods, and such parts, are all enclosed and are continuously lubricated. Roller bearings are used in all the axleboxes. The suspension springs are above the axleboxes and are carried inside the box frame. Both the axleboxes and the springs are under continuous lubrication. As any marked increase in thermal efficiency and power output is improbable with piston valves as now arranged, the further improvement desired had to be sought in other directions.

A new design of cylinder, incorporating a sleeve valve, has been introduced and has been tested on a converted Atlantic locomotive, No. 2039, *Hartland Point*. The admission of steam into the cylinder, and the exhaust from it, is controlled by a single sleeve, inside which is the piston. This sleeve is made of cast iron and slides inside liners of cast iron, which are pressed into the fabricated steel cylinders. A system of levers imparts a certain degree of axial rotation to the sleeve during the course of its travel.

The steam admission and exhaust ports are machined in the sleeve, and are equally



Outline diagram showing the general design of the « Leader » class tank locomotive.

distributed around the circumference, so as not to impede the flow of steam into the cylinder and the exhaust steam to the blast pipe.

The steam and exhaust ports are separate, whereas in the ordinary type of locomotive cylinder the same passages convey both live and exhaust steam to and from the cylinders. In the « Leader » class the steamchest volume is  $3\frac{1}{2}$  times the cylinder volume at maximum cut-off. The ratio of the port area to the cylinder area, as compared with the « West Country » class, is 1·9/1. The clearance volume is only 6 per cent. These three features—greater steamchest volume, increased port area, and reduced clearance volume—should, in the designer's opinion, increase the thermal efficiency appreciably.

The boiler is of welded construction throughout, and does not contain a single rivet. The usual firebox, with water-legs, has been eliminated, and its place is taken by four thermic syphons in conjunction with a round-topped drum and a barrel containing the tubes and superheater flues.

Four thermic syphons are attached to the underside of the drum at the heads of the syphons. The necks of the syphons are attached to the underside of the boiler barrel. These syphons will ensure the circulation of water from the boiler barrel to the drum above the fire, the water passing through the thermic syphons at the hottest part of the furnace. The hot gases will be on both sides of all the syphons, and not (as in the usual water-leg of the firebox) at one side only. This should reduce the maintenance of the firebox, as a large proportion of this maintenance on the water-leg type of firebox is spent on attending to, and renewing, the water-space stays connecting the inner and outer fireboxes.

No trouble from scale is feared, as the T.I.A. water-treatment equipment is being fitted. This is the Traitement Intégral Armand,

standard practice on the French National Railways which now has been introduced on the Southern Region. The water in the tanks and in the boiler is tested chemically every day. The chemical fluid required to treat the water is displaced automatically from the tank in which it is carried, in proportion to the quantity of water put into the water tank, when water is taken. Its composition is based

alkaline, so corrosion no longer is to be feared.

A manually operated blow-down valve is fitted on the bottom of the firebox and is opened every 30 miles for 30 seconds. This has suppressed priming. Automatic blowing-down has been found ineffective, as the water in the firebox-legs was not disturbed sufficiently to get rid of the mud deposited.

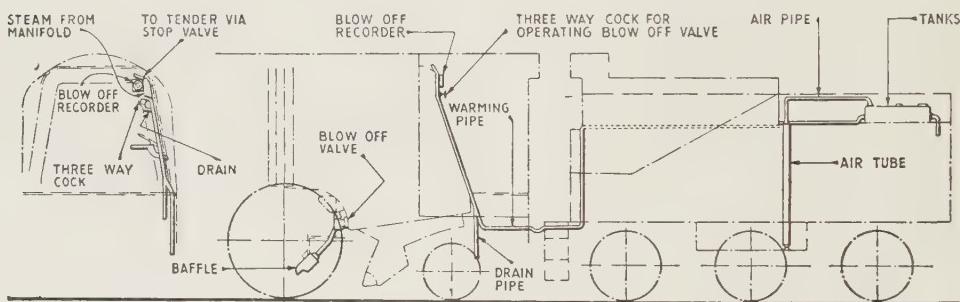


Diagram showing the arrangement of the T.I.A. feed-treatment process in a Southern Region Pacific locomotive.

on the water, or waters used, and is varied to meet the conditions revealed by the daily examination.

This treatment neutralises the ill effects of the oxygen and the carbon dioxide in the water, and all the scale-forming constituents in the water are precipitated in the form of a soft non-adhering mud. The water is brought down to zero hardness, and is made

This system of boiler water treatment has made it possible to increase the periods between boiler washings from 7 days to 2 months. Moreover, the boilers which showed scaling before treatment, now are completely free from any traces of it. The period of 2 months has been selected, because it is felt desirable to inspect the firebox plates and stays at this interval.

## **Actual state of Railway electrification in the world.**

*(Continued) (\*)*

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Further to the article appearing under the same heading in our *Bulletin* for April 1949, we publish hereafter in a similar manner, the replies which we have received afterwards from various Railway Administrations, concerning the investigation made by the International Railway Congress Association regarding the actual state of railway electrification in the world. This investigation was made at the request of the British Railways.

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(\*) See *Bulletin* for April 1949, p. 271.

	COUNTRIES	ITALY	AUSTRALIA
	RAILWAY ADMINISTRATION	Italian State Railways	Victorian State Railways
I. Length of the electrified system.			
— main tracks . . . . . (miles)		—	349
— secondary tracks . . . . . »		—	—
— total mileage. . . . . »	6 820		438
— main lines . . . . . »	2 835		—
— secondary lines . . . . . »	414		—
— total mileage. . . . . »	3 250		173
II. Feeding current.			
— nature . . . . .	Triphase $16\frac{2}{3}$ p. s.	Direct 3 000 and 800 V.	Direct
— tension . . . . .	3 700 V.	750 V.	1 500 V.
— kind of feeder . . . . .	Catenary	3rd rail	Catenary.
III. Year of electrification.		1901 to 1948	1919
IV. Kind of traffic . . . . .		Passengers-goods.	Passengers-goods.
V. Reasons and results of the electrification . . . . .			
	Reduction of coal and fuel imports.		Metropolitan traffic forms 40% of total train mileage.
	Use of national production of electrical energy (white coal and geothermic).		Growth of population in suburbs.
	Favourable operating conditions on gradients and in tunnels.		Increase of speed and frequency of train services.
	Reduction of operating costs.		Increase of comfort and safety.
	Satisfactory results.		Abolition of dirt, smoke, noise and smell.
			Improved lighting and cleanliness of carriages.
			Saving of fuel.
			Reduction of operating expenses.
VI. Electric locomotives.			
Total number of the stock . . . max. speed	1 415		12
— passenger . . . . . max. speed	429	/80 m. p. h.	—
— freight . . . . . max. speed	986		12 /40 m. p. h.
— composite . . . . . max. speed		—	—
— other types. . . . . max. speed		—	—
VII. Electric motor coaches.			
— total number of the stock . . . . .	247		884
— motor coaches . . . . .	215		402
— trailers. . . . .	32		482
— maximum speed. . . . .	80 m. p. h.		50 m. p. h.
VIII. Annual consumption in millions of Kwh. (year) . . . . .	1 000		164

(1) Plus 389½ miles of lines (697 miles of track) under construction.

(2) Change from 1 500 V. to 3 000 V. will be arranged shortly.

(3) Plus 40 high speed locomotives and 10 shunting locomotives under construction.

NEW ZEALAND	SOUTH AFRICA	BELGIUM	INDIA
New Zealand Governement Railways.	South African Railways and Harbours.	Belgian National Railways.	Bombay, Baroda and Central India Railway.
38	—	54	91,6
—	—	—	—
45	1 199	54	107,5
—	— (1)	27	—
—	—	—	—
45	584	27 (4)	36,8
Direct 1 500 V. Catenary.	Direct. 1 500 V. (Cape) (2) 3 000 V. Orange, Natal and Transv. Catenary.	Direct 3 000 V. Catenary.	Direct 1 500 V. Catenary.
1923 to 1940	1925 to 1938	1935	1928 to 1936
Passengers-goods.	Passengers-goods.	Passengers.	Passengers (Suburb. serv.)
Increased haulage on gradients. Elimination of smoke in tunnels.	Natal. Important traffic on gradient lines. <i>Cape.</i> Heavy traffic in Cape suburban area. (3 times more than in 1923). <i>Transvaal.</i> Increase of goods and passenger traffic occasioned by the expansion of the gold mines (5 times more passengers than in 1934). Good results from the economic, operating and comfort points of view.	Modernization of passenger services on the most important line of the system. Very satisfactory results. Important increase of traffic (7 trains per hour at rush hours of the day). The electrified line represents 0.8% of the total mileage and 8% of the total passenger traffic of the system are conveyed.	Provide numerous fast trains between Bombay and its suburbs to cope with the heavy increase of passengers living in the suburbs. Very satisfactory results. Operating more economical than with steam traction.
21	203 (3)	Nil (5)	Nil.
—	—		
21 /50 m. p. h.	203 /60 p. m. h. 12		
17 9 8 40 m.p.h.	829 269 560 60 m. p. h.	82 (6) 42 40 74 to 80 m. p .h.	161 41 120 52 m. p. h.
10.6	459		48.5

(4) Plus 84.5 miles of double track lines being electrified.

(5) 26 BB passenger-goods locomotives (max. speed 62 to 80 m. p. h.) under construction.

(6) 12 quadruple motor coaches (M.-R.-R.-M.); 16 trailers; 9 double motor coaches. Under construction : 25 double motor coaches.

	COUNTRIES	INDIA	
	RAILWAY ADMINISTRATION	Great Indian Peninsula Railway	South Indian Railway (Madras Beach to Jambaran)
I. Length of the electrified system.			
— main tracks . . . . . (miles)	426		18
— secondary tracks . . . . . »	—		—
— total mileage . . . . . »	575		43
— main lines . . . . . »	—		—
— secondary lines . . . . . »	—		—
— total mileage . . . . . »	182		36
II. Feeding current.			
— nature . . . . .	Direct 1 500 V.		Direct 1 500 V.
— tension . . . . .	Catenary.		Catenary.
— kind of feeder. . . . .			
III. Year of electrification . . . . .	1925-1929		1931
IV. Kind of traffic . . . . .	Passengers-goods.		Passengers-goods.
V. Reasons and results of the electrification. . . . .	Increase of the capacity of suburban lines by increasing the speed and frequency of trains.  Increase of loading capacity of goods trains. Satisfactory results.		Provision of suburban services to the city and suburbs of Madras.  Increase of the traffic.
VI. Electric locomotives.			
Total number of the stock . . . max. speed	66		4
— passenger . . . . . max. speed	25 /85 m. p. h.		—
— freight . . . . . max. speed	41 /43 m. p. h.		—
— composite . . . . . max. speed	—		4 /45 m. p. h.
— other types. . . . . max. speed	—		—
VII. Electric motor coaches.			
— total number of the stock . . . . .	206		72
— motor coaches. . . . .	53		24
— trailers . . . . .	153		48
— maximum speed . . . . .	55 m. p. h.		50 m. p. h.
VIII. Annual consumption in millions of Kwh. (year). . . . .	301		6.3

(1) The suburban lines were electrified since 1893 (550 V. D. C.). The change over to 1 500 V. was started in 19

SWEDEN	SPAIN			
Stockholm-Roslagens Järnvägar	Spanish National Railways ("RENFE")	Spanish National Railways ("RENFE")	Spanish National Railways ("RENFE")	Spanish National Railways ("RENFE")
61	18	38	303	222
—	—	—	—	—
79	20	53	385	261
—	18	38	—	—
—	—	—	—	—
53	18	38	184	148
Direct 1 500 V. (1) Catenary.	Triphase 6 000 V. —	Direct 3 000 V. Catenary.	Direct 1 500 V. Catenary.	Direct 1 650 V. Catenary.
1937 to 1945	1911	1924	1927 to 1931	1928 and 1946
Passengers-goods.	Passengers-goods.	Passengers-goods.	Passengers-goods.	Passengers-goods.
Necessity of increasing the capacity of suburban lines. Shortage of fuel during the war. satisfactory results.	Necessity of increasing the capacity of lines (gradients of 27 ‰) for the ore traffic. Electrification has increased 3 times the capacity.	Coal traffic on steep gradients (20%). Abolition of smoke in tunnels. Replacement of 30 steam locomotives by 10 electric locomotives. Reduction of 55% of energy consumption. Reduction of 73.5% of the maintenance and repair costs of the locomotives. Reduction of 63% of running staff costs. Reduction of 31% tonne-kilometre cost.	Necessity of increasing the capacity of the line. Heavy suburban passenger traffic. Increase of the average speed of the trains by 45%. Increase of the capacity of the lines. Extension of suburban services, difficult to carry out with steam traction.	
6	7 /15 m. p. h.	12 /37 m. p. h.	55 /68 m. p. h.	43 /68 m. p. h.
—	—	—	—	—
6 /45 m. p. h.	—	—	13 /55 m. p. h.	24 /55 m. p. h.
—	—	—	—	—
114 23 91 31 to 45 p. m. h.	Nil.	Nil.	59 — — 62 m. p. h.	30 — — 62 m. p. h.
10.1	0.86 (1947)	0.01	62.4 (1947)	27

## ERRATA

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### Bulletin, April 1949 number.

REPORT ON QUESTION II (*Enlarged Meeting of the Permanent Commission, Lisbon 1949*), by Dr. E. MEYER and Ch. STHIOUL :

- page 273/19, 2nd column, 25th line, *there is* :  
The absorption of the energy produced during braking is not difficult.  
*instead of* : ... is most difficult.
  - page 276/22, 2nd column, 28th line, *there is* :  
than any increase in speed.  
*instead of* : ... increase of the maximum speed.
  - page 276/22, 2nd column, 30th line, *there is* :  
... fixed in the Regulations by the formula...  
*instead of* : ... fixed as a rule by the formula...
  - page 315/61, 1st column, 19th line, *there is* :  
... masses which tend to...  
*instead of* : ... masses which tends to...
  - page 321/67, 1st column, 40th line, *there is* :  
Usually it is between 200...  
*instead of* : ... Usually it is between 2 000...
  - page 323/69, 1st column, *there is* :  
... reduction motors...  
*instead of* : ... induction motors.
-